



Ministry
of Defence

Combat Air Strategy:

An ambitious vision for the future



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Foreword

by The Secretary of State for Defence



The United Kingdom has been a pioneer in air power for more than 100 years. As the Royal Air Force enters its second century, we celebrate their continuous contribution to protecting our people and safeguarding our national interests. We have consistently demonstrated our prowess for invention and innovation, including the first purpose built air-to-air combat aircraft, the first ground-based integrated radar defence system, the turbojet engine and the first vertical take-off and landing aircraft. Building on our proud history and to ensure we secure world-leading capability, I am launching a new capability acquisition programme to replace Typhoon when it leaves Royal Air Force service – an exciting first step into a second century of UK Combat Air capability.

Our technical and industrial expertise has put the UK at the heart of successful international collaborations including Tornado, Typhoon and F-35. The UK Combat Air industry has delivered significant economic benefit to the UK, through the development of the most advanced technologies, employment of a highly skilled workforce and huge success in the export market. The sector has grown to an annual turnover of over £6Bn, directly supporting over 18,000 jobs and more than 2000 companies across England, Scotland, Wales and Northern Ireland, with many thousands more across the supply chain. The Combat Air sector delivers UK jobs, UK design, UK innovation and UK sovereign capability by taking an innovative and international approach. This Strategy lays out a vision for how the UK will remain at the forefront in this critical sector as we leave the EU; ensuring we can continue to make a pivotal contribution to European and global security.

A strong national Combat Air sector gives the UK the military capability we need to defend the country and our national interests, and choice in how we provide that capability without relying on others – the very essence of sovereignty. We face a more complex and uncertain world than ever, demanding a robust and agile national response. The world-class industrial, technical and scientific know-how which underpins our success in Combat Air has been hard won and we are now at a pivotal moment – a juncture where we need to act if we are to keep highly skilled jobs and world-class sovereign technologies. We could choose to let this essential industry die; the Strategy creates the conditions for it to thrive and grow.

Our vision is for the UK to remain at the leading edge of Combat Air system development to protect our people, project influence and promote our prosperity. To do this the Ministry of Defence and industry must build on success, rapidly change our approach and work together to achieve common goals. We must develop more capability, more quickly, for less. It is nearly 40 years since Typhoon was conceived, in that time technology has revolutionised all aspects of life from the arrival of the internet to the latest IT and smartphone technologies. Defence and the Combat Air sector must develop the tools and approaches to embrace the pace of technological change seen across all industrial sectors.

The UK already has a long and proud history of delivering world-class Combat Air systems through collaborative programmes. We also have a unique global network of international partners in Combat Air which we will develop even further to maximise mutual benefit and reinforce our ability to operate together. This Strategy sets out how we will deliver this agenda.

This Combat Air Strategy is a crucial pillar of the Government's Modernising Defence Programme. It sets out our aspirations and identifies how we will make this vision real, giving industry and international partners a clear signal of our national intent and our desire to work together. Our investment of nearly £2Bn over ten years in the Future Combat Air System Technology Initiative provides the means to develop the technologies of the future. The Strategy confirms investments in and upgrades to existing capabilities such as Typhoon and F-35 to keep them at the cutting edge well into the future.

The Strategy builds on success and enables us to deliver the UK's – and our partners' – future military capabilities. This will ensure a sustainable and globally competitive industry in the UK for the long term. It will deliver a strategic approach to defence acquisition which maximises the value to the UK.

A handwritten signature in black ink, appearing to read 'Gavin Williamson', with a long horizontal line extending to the right.

The Rt Hon Gavin Williamson CBE MP
Secretary of State for Defence

Executive Summary

1. The 2015 Strategic Defence and Security Review and the 2018 National Security Capability Review outlined an intensifying and evolving threat picture and confirmed investment in the next generation of Combat Air technology in partnership with our defence aerospace industry and our closest allies. The UK's ability to generate and employ Combat Air power therefore remains critical to delivering our national security and to supporting the Government's vision for a strong, prosperous, influential and global Britain.
2. The UK is a global leader in Combat Air, with cutting-edge military capability underpinned by world-class industrial, technical and scientific know-how. The UK Combat Air sector has an annual turnover of over £6Bn and directly supports over 18,000 skilled jobs across the UK with many more in the wider supply chain.
3. The 2015 Strategic Defence and Security Review established the Future Combat Air Systems Technology Initiative to sustain investment in the Combat Air sector. This remains critical if the UK is to continue to develop next generation technology. Without sustained investment our advantage would rapidly decline.
4. Operational advantage and freedom of action in Combat Air enables the UK to achieve our military and strategic objectives, but the threat we face is evolving and proliferating ever more rapidly.
5. Our Combat Air capability will largely be based around Typhoon and F-35 for the coming decades. By investing in the continuous development of these capabilities we can ensure the future force remains world-class. We will continue to take the best of these capabilities and spiral-develop them into any future system we may develop.
6. We anticipate the future air environment will become increasingly complex, with rapid technological advancements especially in sensing, data management and autonomy. We believe that information advantage will be critical, as will the ability to exploit and defeat emerging technologies.
7. The UK's ability to choose how we deliver our future requirements (including maintenance and upgrade of current systems) is dependent on maintaining access to a dynamic and innovative industrial base. The Strategy highlights the criticality of cutting-edge UK technology and Intellectual Property, including how this is generated, sustained and exploited.
8. This Strategy defines a clear way ahead, to preserve our national advantage and maintain choice in how it is delivered:
 - The Ministry of Defence will continue to invest in upgrading Typhoon, continuously improving its systems to achieve a 'beyond-4th generation' capability.

- By implementing the Future Combat Air System Technology Initiative, established by the 2015 Strategic Defence and Security Review, including commencing the critical next phase of the National Programme, we will provide investment in key UK design engineering skills and a means to generate UK Intellectual Property.
 - The Ministry of Defence will now initiate the UK's capability acquisition programme to define and deliver the future capabilities required when Typhoon leaves Royal Air Force service. This will deliver a Strategic Outline Business Case for the Typhoon successor by the end of 2018, with an initial acquisition decision by the end of 2020.
 - Government and industry will work together to achieve a more open and sustainable industrial base which invests in its own future, partners internationally and breaks the cycle of increasing cost and length of Combat Air development programmes.
 - The UK will take a strategic approach to Combat Air, using a National Value Framework that maximises the overall value the UK derives from the sector. We will seek to balance military capability, international influence, economic and prosperity benefits.
 - Effective international partnering in Combat Air is fundamental to the delivery of our national goals and management of cost. The UK has a unique network of capability collaborations and will work quickly and openly with allies to build on or establish new partnerships to deliver future requirements.
9. The Government will take forward this programme of work to preserve the UK's operational advantage and freedom of action while maximising the economic and strategic benefits that result from the UK playing a major role in any future Combat Air acquisition programme.

Operational Advantage:

The ability to find and maintain an edge over potential adversaries, both to increase the chances of our success in hostile situations and to increase the protection of the UK assets involved, especially our people.

Freedom of Action:

The ability to determine our internal and external affairs and act in the country's interests free from intervention by other states or entities, in accordance with our legal obligations.

Introduction

This document initiates a strategic approach to the UK's Combat Air sector. As a first step it sets an ambitious vision for the future and confirms how the UK will retain its ability to choose how we meet our future requirements.

The Strategy identifies decisions we need to make now and sets a framework and roadmap for future decisions. It challenges Government and industry to cooperate in transforming our approach to the sector, driving pace and affordability. It gives our international partners a clear signal of our intent and proposes rapid further engagement. Finally, it confirms we will commence the next phase of the technology demonstration programme established by the 2015 Strategic Defence and Security Review and initiates the long-term capability acquisition programme that will underpin our future capability delivery. The Ministry of Defence will develop a detailed implementation plan with partners to deliver the objectives of the Strategy and prepare the groundwork for the UK's future acquisition decisions.



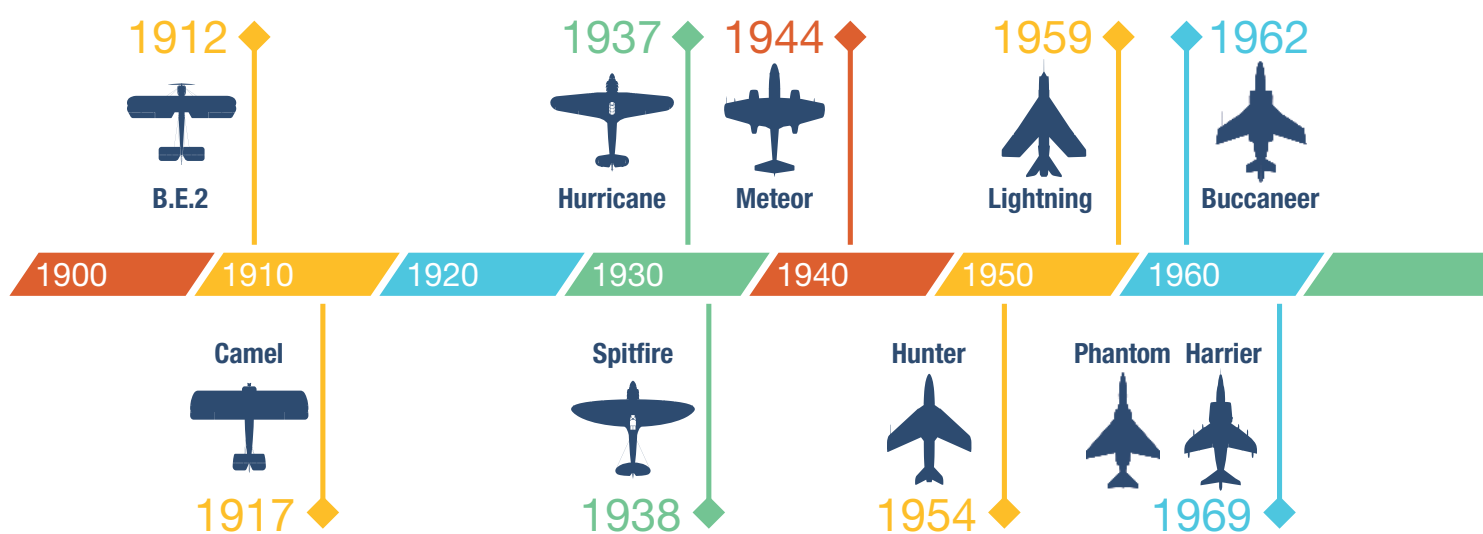
Chapter 1

Strategic Context

- The UK's ability to employ air power remains critical to delivering our national security and supports the Government's vision for a strong, prosperous, influential and global Britain.
- As confirmed in the 2018 National Security Capability Review the threats we face are increasingly complex and diverse. We expect this trend to continue in the coming years.
- Our national advantage is defined by our ability to design, develop, upgrade and certify capabilities to address evolving threats and meet operational requirements.
- The UK Combat Air industry requires clarity of our approach and continuing investment in next generation capability.

The importance of Combat Air to the UK

1. Air power is critical to our ability to deliver our national security and to support the Government's vision for a strong, prosperous, influential and global Britain. The air power attributes of height, speed, reach, agility and ubiquity provide a responsive and scalable military tool of national power. Combat Air is a critical component of air power and has made a major contribution to UK operational success since the formation of the Royal Air Force 100 years ago.
2. The ability to deter and defeat potential adversaries and to do so at a time and place of our choosing in Combat Air are prerequisites to the UK's ability to deliver its defence, foreign policy and economic objectives. Our **operational advantage** ensures that the UK can deliver Control of the air and Attack functions successfully and our **freedom of action** means we can act free from intervention by other states or entities.



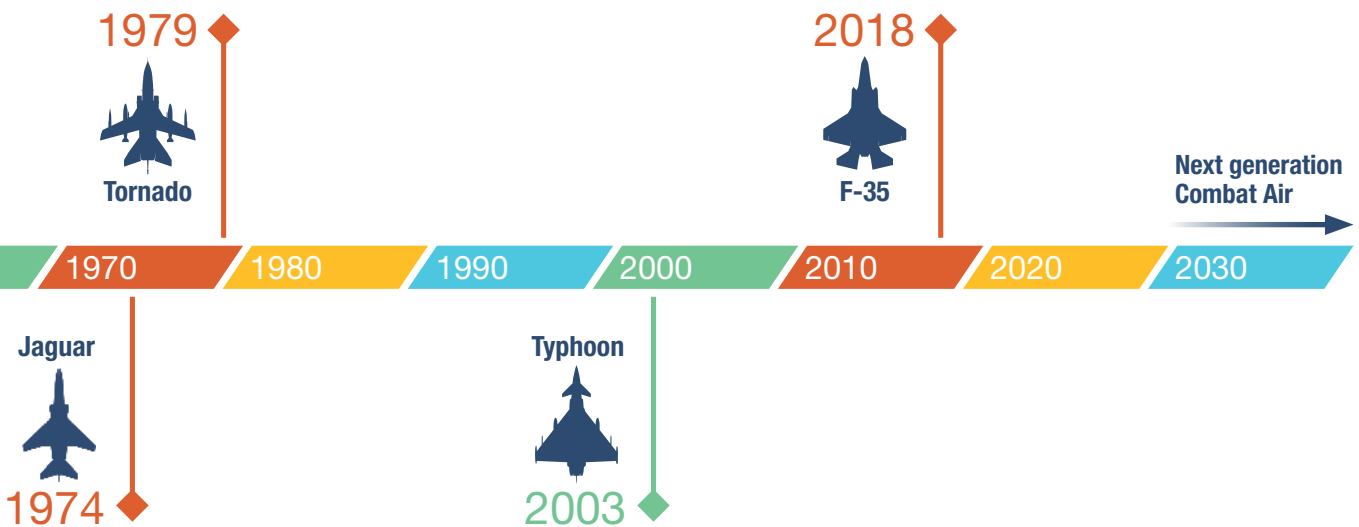
- Following the retirement of Tornado in 2019, the UK's Combat Air requirements will be delivered through a combination of upgraded Typhoon and F-35. The 2015 Strategic Defence and Security Review committed to an extensive programme of upgrades to ensure Typhoon's operational effectiveness and to enable the aircraft to operate with the Royal Air Force until at least 2040.

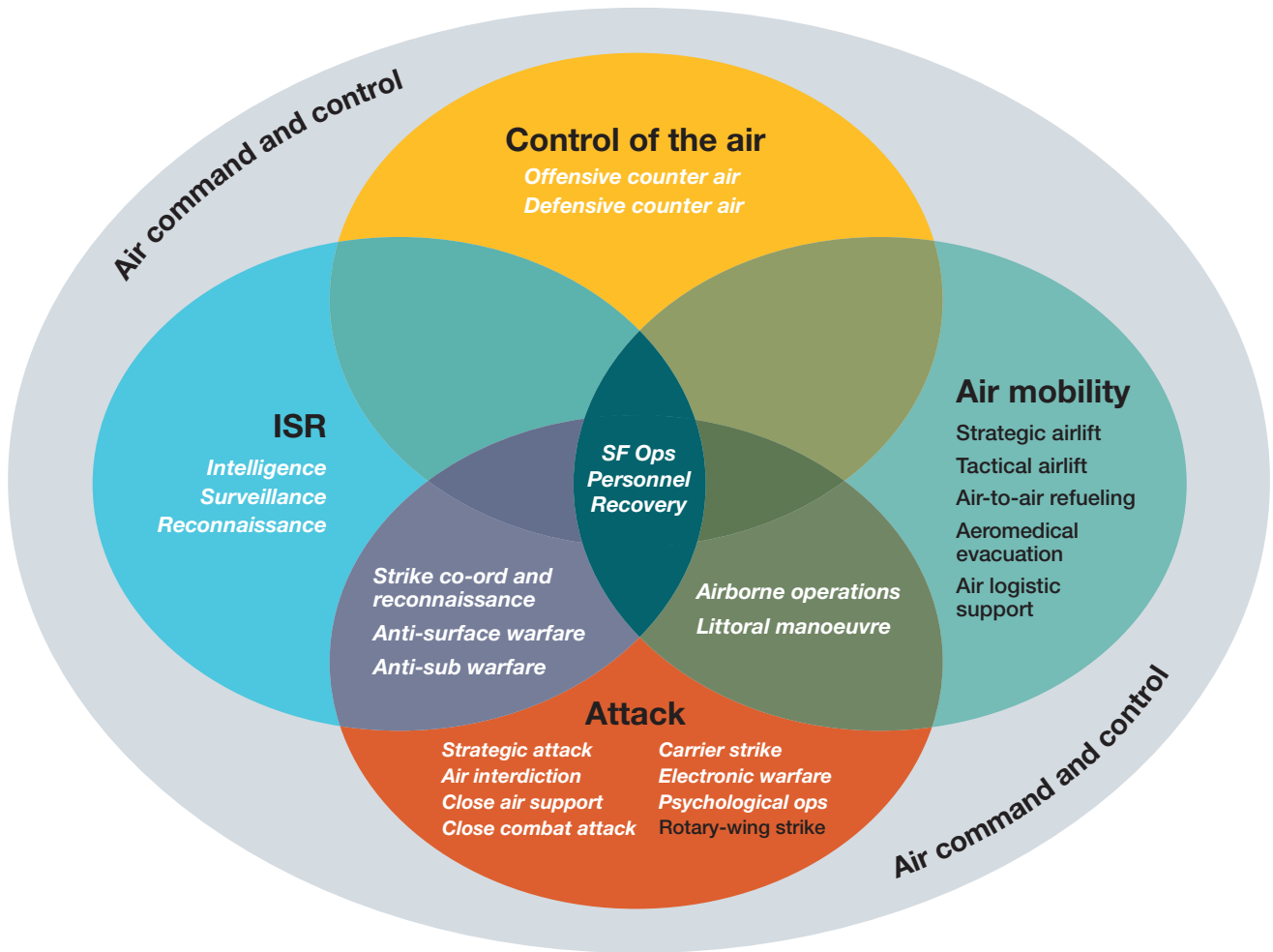
The Challenge

- The roles and demands we place on Combat Air have evolved significantly over time and the threats and counters to their capabilities have also become more complex. High capability threat systems have proliferated widely in the last 20 years, both to state and non-state actors, and we expect this trend to continue. Upgrades to the legacy systems of potential adversaries and the increasing availability of off-the-shelf options mean threat systems are ever more versatile, affordable and adaptable, particularly as they become more software-enabled.
- For much of the last two decades the UK and our allies focused our attention on counter-insurgency operations in environments where we were largely unchallenged in the air domain. Investment by adversaries in highly capable systems has reduced the technological advantage that Western air forces have in achieving and maintaining control of the air.
- The 2018 National Security Capability Review highlighted that the world has become more uncertain and volatile since 2015. In 2017 the Ministry of Defence's Development, Concepts and Doctrine Centre produced the Future Force Concept, which concluded that the future air domain will continue to be characterised by highly-capable integrated air defence systems and an increasingly complex electro-magnetic environment. Space and

Combat Air:

An aircraft, manned or unmanned, whose prime function is to conduct air-to-air and/or air-to-surface combat operations in a hostile and/or contested environment, whilst having the ability to concurrently conduct surveillance, reconnaissance, electronic warfare and command and control tasks.





The four roles of air power

Combat Air elements shown in white italics

Cyber domains will also become increasingly important as we seek to maintain information advantage. Combat Air systems will need to be agile and adaptable to address this future environment and we will need to harness technological change over their lifetimes.

7. The integration of more technology and the increasing complexity of Combat Air systems drives greater cost into programmes. To counter threats effectively, governments are therefore forced to trade between capability and platform numbers to ensure programmes remain affordable, while driving existing platforms to remain in service longer. Increases in service life of systems, alongside greater time between project initiation and delivery creates greater risk of early obsolescence and irrelevance. This underlines both the importance and challenge of maintaining world-leading industrial skills and delivering and updating with pace to field systems which remain relevant in rapidly evolving environments.



A Russian SU-27 Flanker with RAF Typhoon escort

A Successful and World-Class Industrial Base

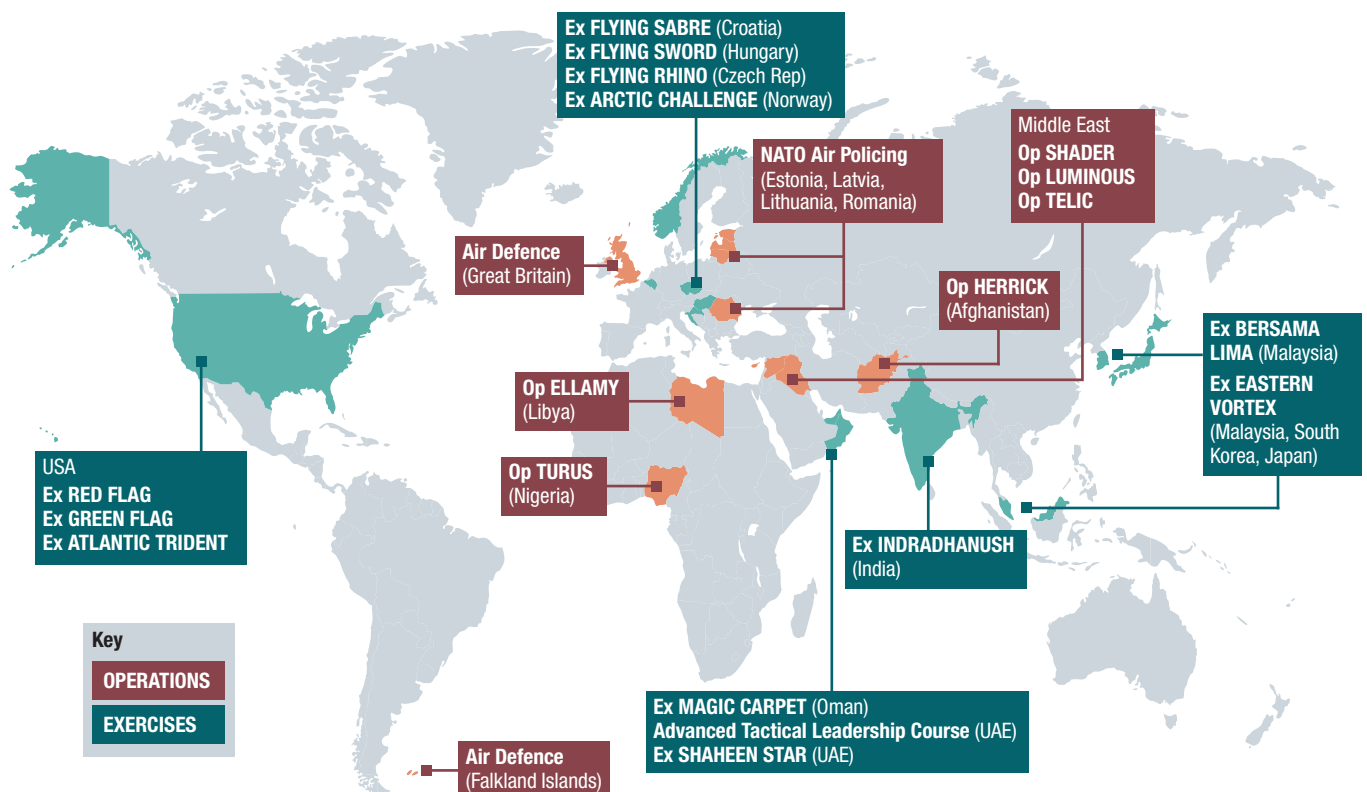
8. The UK has a truly world-class Combat Air sector, developed over the last 100 years and most recently through the collaborative programmes to deliver Tornado, Typhoon and F-35. This experience and our related research and development investment means the UK is well positioned to deliver next generation capability together with partners and allies.
9. The UK has enjoyed significant success exporting Combat Air sector capabilities including platforms, sub-systems, training and support solutions. Over the last decade, Defence aerospace, including Tornado, Typhoon, Hawk and F-35 global support, has accounted for over 80% of the UK's annual defence export orders of around £6Bn. The export of Typhoon has been particularly important in UK Complex Weapons exports, reducing the cost to the Ministry of Defence of key weapons capabilities.

UK Combat Air Sector:

Key Facts

- Considered an economically strategic sector
- Provides highly skilled jobs, promotes technology spill-overs and fosters regional development
- Annual turnover: ~£6.5Bn
- Annual R&D investment: ~£230M
- Directly supports: ~18,000 jobs
- Creates ~28,000 jobs in the supply chain across ~2,000 companies

2016 data (RAND PR-3704-MOD, May 2018)



Recent Royal Air Force Combat Air Exercises and Operational Deployments



F-35

The UK is the only Tier 1 partner on the F-35 programme. The experience and Intellectual Property from programmes including Harrier, Tornado and Typhoon meant that the UK could bring world-leading technology to this US-led programme. As a result, UK companies deliver around 15% of every aircraft in the biggest defence programme in history. This supports a supply chain in the UK of over 500 companies.

A UK F-35B Lightning II

10. UK Intellectual Property was critical in securing the UK's enhanced industrial position in the F-35 programme. Our early involvement during the design and development phases ensured better delivery against US and UK requirements, and has allowed the UK to compete successfully for key elements of the F-35 Global Support Solution.



BAE Systems workers assembling the rear fuselage for the F-35 Lightning II, at their state of the art advanced manufacturing and assembly facilities in Lancashire, UK.

The Industrial Challenge

11. The decision in the 2015 Strategic Defence and Security Review to upgrade and extend Typhoon in service will allow us to get the most from this highly capable multi-role platform. The programme of planned enhancements to Typhoon, especially in sensors and weapons, will ensure it remains highly operationally effective and commercially competitive for decades to come.
12. This decision will, however, extend the gap between major air system design phases. Recent Typhoon and F-35-related work and success in Typhoon exports provides significant revenue for the UK and will sustain Typhoon manufacturing into the 2020s. Without a clear indication of future UK requirements this is not enough to stimulate the research and development investment necessary to refresh national Intellectual Property, placing key engineering skills at greater risk.

13. The 2015 Strategic Defence and Security Review also initiated the Future Combat Air System Technology Initiative to bridge this gap. This enables over £2Bn of joint Government and industry investment in sustaining and enhancing key skills and capacity into the 2020s. By continuing to implement this policy, including the critical next phase of the National Programme, we will provide investment in key UK design engineering skills and a means to generate UK Intellectual Property. This will help to maintain long-term choice for future UK Combat Air system acquisition and ensure a major role for UK industry in delivering the systems that succeed Typhoon.

The Opportunity

14. The UK has a unique heritage of global cooperation. We are working with the United States to deliver the world-class F-35, we continue to enjoy highly successful partnerships across Europe, and we continue to build on relationships with international partners and allies. The UK has had significant success in the export market,

selling to and partnering with nations to enable them to deliver their military, strategic and economic objectives. Most recently UK industry has diversified further, building on our national investment and world-class status to provide technical consultancy to key partner nations, helping them achieve their own capability and industrial objectives. International partnering presents a strategic opportunity to better deliver UK objectives and those of allies and partners.

15. Fourth generation combat aircraft, which include Typhoon, Rafale, F-16, F-18 and Gripen, will start to be retired from service in the late 2030s. Typhoon platform and system upgrades will ensure it remains operationally competitive well beyond this point, but there will be a significant market for a successor to these capabilities over the period 2040-2060. The UK's experience in developing Tornado and Typhoon, on the F-35 programme and integrating 4th and 5th generation systems means we are ideally placed to work with a wide range of partners to achieve first mover advantage within this market.



Royal Air Force Typhoon and Indian Sukhoi Su-30s in formation

Chapter 2

Industrial Landscape

- The trend of successive Combat Air systems costing more and taking longer to develop must be addressed urgently.
- UK-generated Intellectual Property, people, skills and facilities in the Combat Air sector are critical to sustaining UK operational advantage and freedom of action.
- Successful implementation of this Strategy depends on a change in behaviour within both industry and government.
- To meet our future requirements the UK needs a forward-thinking and innovative industrial base which invests in its own future.
- Industry's approach should include the whole supply chain, fully integrate through-life support issues and engage effectively with wider civil and technology sectors.

Industrial Heritage

16. The UK industrial sector has successfully underpinned our operational advantage and freedom of action in the Combat Air sector for the last 100 years. It is also key to enabling UK capability assurance. This has been achieved through the indigenous ability to design, develop, upgrade, certify and support our Combat Air systems. A capable industrial base allows us to develop solutions to meet our requirements, be they military, political, or financial. It also enables greater national control over the cost and risk of delivering capability.

Delivering Future Capability

17. Successive Combat Air systems have cost more and taken longer to develop than their predecessors. This is not the case in other technologically-driven sectors, such as automotive, and this trend needs to be addressed urgently in Combat Air. Technological and process developments from wider industry offer the opportunity to change this paradigm. Some of these approaches have already been implemented successfully to drive down the significant support costs for our Combat Air systems.

Dual-mode Brimstone: a rapid response to an urgent need

In 2007 the Royal Air Force identified the need for a low collateral damage precision strike capability for Iraq and Afghanistan. An innovative Ministry of Defence-industry partnership delivered in just 18 months. MBDA developed a new, dual-mode seeker by converting existing single-mode, 'fire-and-forget' Brimstone missiles, significantly reducing the timescale to deliver the required capability. The resulting weapon, continuously updated, remains the bedrock of the Royal Air Force's precision strike capability.





TyTAN: the Typhoon Total Availability Enterprise

TyTAN is an innovative commercial agreement which will reduce Typhoon support costs by over 30% over 10 years. It aligns the long-term strategic needs and aspirations of the Ministry of Defence and industrial partners. The 10-year duration provides security for industry to invest in transformative change. The benefits of cost reduction are shared and then reinvested into the programme. TyTAN will recycle over £500M support savings to increase Typhoon capability.

18. To deliver affordable next generation capability, the UK's Combat Air industry will need to deliver ever increasing levels of productivity, efficiency and sustainability throughout the supply chain. This will require greater innovation and diversification, particularly at the prime contractor level to reduce reliance on platform-driven acquisitions, as capability becomes more dependent on a system of systems approach.
19. The Combat Air sector requires a particularly wide range of core skills. Some are specific to the sector and require bespoke investment by national champions, including in systems integration, propulsion, sensors and weapons. However, others are common to a range of wider industry, high technology, manufacturing and aerospace sectors. To remain affordable and sustainable the Combat Air sector needs to evolve fast to engage with and leverage the best of wider industry. The Department for Business, Energy and Industrial Strategy and the Ministry of Defence will work together to develop the means to incentivise greater involvement of the wider UK skills base.

20. Combat Air will be increasingly defined by winning the information battle: collecting, processing, sharing, exploiting and protecting data. The wider UK industrial base has world-class expertise in this area, and access to wider global innovation. This must be fully integrated into industrial solutions and the Combat Air industry needs to respond imaginatively and inclusively to this opportunity.

PYRAMID: a UK-developed Open System Architecture

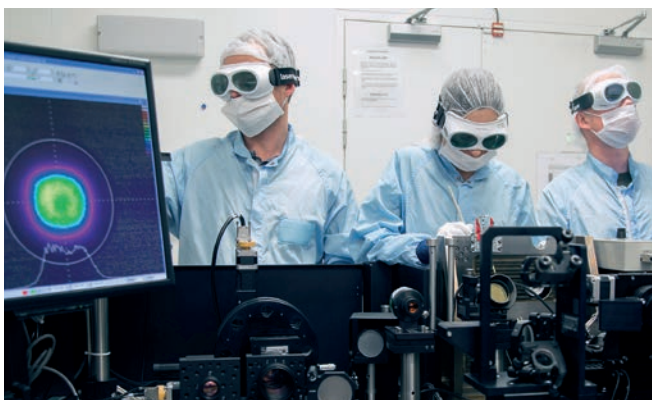
Mission systems software is becoming ever more complex and is a major driver of cost. The pace of technological changes means the software must be easily adapted to respond to evolving threats and capability needs. A reusable and open core mission system architecture and a suite of reusable, functional software components are being developed by the UK for current and future systems. This approach will enable systematic re-use, reducing costs of software development and support and time to implement capability enhancements while enabling greater interoperability across systems. This approach will also allow partners or export customers to integrate their own mission system fits quickly and easily.

21. The UK has a long history of success in international partnering and exporting defence capabilities. Key to the health of the Combat Air related industrial base is continued success in the international market. To achieve this, future systems must be designed with international partners and the global market at the forefront. Taking an open system architecture approach will allow partners' needs to be met by rapidly and cost-effectively integrating a range of capabilities on a common framework.

Investment in UK Capabilities

22. UK-generated Intellectual Property, people, skills and facilities are critical to sustaining operational advantage and freedom of action, securing our national prosperity and the UK's position as a defence exporter. They are also key to enabling choice in future acquisition and international partnering. Industry investment in UK Intellectual Property should be aligned to those technologies that can be exploited to secure operational advantage and freedom of action or export opportunities.

23. To enable this, the UK Government will provide greater clarity on future national Combat Air capability requirements. The Ministry of Defence will work with industry, including small and medium-sized enterprises and industry bodies, to define and prioritise investment in the technologies that are critical to sustain our operational advantage and freedom of action requirements. This Strategy confirms our long-term national intent, enabling industry to respond and invest accordingly.



Laser production at Leonardo, Edinburgh, UK

Advanced Manufacturing Research Centre

The Advanced Manufacturing Research Centre was established as a partnership between the University of Sheffield and Boeing over 15 years ago. It is a magnet to cutting-edge companies attracted by the world-leading R&D output. Now over 100 industry partners work through the AMRC and it is a core part of the Government-supported High Value Manufacturing Catapult. It has created a world-leading facility in an area with high unemployment.



Challenge to Industry

24. To meet our future requirements, UK companies need to be able to work together to deliver affordable next generation technology that meets our national objectives. To become sustainable, UK industry must focus on delivering success in an increasingly competitive global market, invest to secure its world-leading position in this field and continue to partner internationally.

25. The Government looks to industry to embrace this challenge and:
- a. increase its self-funded investment in research and development, including technology demonstrations, to de-risk key technologies prior to full acquisition programmes and embrace the opportunity to fail fast and learn from the experience;
 - b. address urgently the trend of ever more expensive and complex Combat Air systems and the associated time to bring into service by developing and exploiting new technologies, techniques and processes (such as synthetic design, model-based engineering and rapid prototyping);
 - c. build on UK expertise derived from Typhoon and F-35 support solutions to develop innovative plans for driving down the through-life costs of programmes;
 - d. foster a culture of continuous improvement and efficiency to ensure the costs of development and manufacturing reduce over the course of the future acquisition programme;
 - e. deliver assured capability by leveraging the best processes and technologies, wherever they are found in the global supply chain, within the constraints of operational advantage and freedom of action. This includes exploitation of UK high-value manufacturing catapaults, small and medium-sized enterprises, international partners' capabilities and civil sector investment to maximise value for money; and
 - f. develop a transparent methodology that links requirements to cost, risk and time to deliver. This will enable Government, the supply chain, potential partners and respective industries to make informed decisions.
26. Changing behaviours in industry and Government is vital to achieving these objectives. These include new, collaborative ways of working which will align incentives, minimise transactional costs and ensure all sides are held to account for performance. The delivery of the Future Combat Air System Technology Initiative is being managed through a pilot project called 'Team Tempest'. This innovative Government-Industry partnership is being used as a catalyst and test bed for these changes.
27. The performance of Team Tempest and wider industry is key to demonstrating that Government and industry can achieve the necessary capability and behavioural change. Our assessment of this performance will be fundamental to programme decisions in 2020. Success will prove that the UK is in a strong position to lead in delivering affordable next generation capability. Alternative options and greater flexibility in our national requirements will have to be considered if performance does not meet expectations.

Team Tempest:

Team Tempest is part of the Future Combat Air System Technology Initiative programme announced in the 2015 Strategic Defence and Security Review. It comprises Ministry of Defence personnel from the Royal Air Force Rapid Capabilities Office, the Defence Science and Technology Laboratory, Defence Equipment & Support and industry partners (BAE Systems, Leonardo, MBDA and Rolls-Royce) who are delivering elements of the programme. Innovation sits at the heart of Team Tempest, building on our strong UK heritage of world-class in-service capabilities, and advanced technology development programmes.



BriteCloud

BriteCloud integrates a sophisticated electronic radar jamming system into a package just a few inches long, to fit into an aircraft's standard chaff and flare dispenser. This off-board capability can be integrated into wider systems, increasing platform survivability. Leonardo began the development activities for the expendable active decoy in 2012, working in collaboration with the UK's Defence Science and Technology Laboratory. A joint project with the Royal Air Force's Rapid Capabilities Office saw BriteCloud on board Tornado GR4 aircraft in March 2018, less than 12 months after joint work commenced.

Technology Spillover: London Underground

As Combat Air systems become more reliant on software, system integrity has had to increase. BAE Systems has exploited the software developed on Typhoon, Tornado, C-130J and Merlin in other sectors where software integrity is critical. This technology currently provides a Rail Timetabling System for the London Underground, scheduling 1.7M journeys a year on the world's most complex underground system. This mission critical software ensures rolling stock and staff are where they need to be to the second to increase capacity on the network.



Chapter 3

International by Design

- **Effective international partnering offers the UK the best opportunity to deliver affordable military capability and our wider national objectives, while maintaining operational advantage and freedom of action.**
- **The UK is in a strong international position thanks to our historic investment in the air domain, we have a world-class industrial base and highly successful framework of international partnerships.**
- **The UK will work collaboratively to define the best partnering construct to develop the next generation capability.**
- **International partnering in this sector extends beyond capability acquisition and is critical to our operational effectiveness and our ability to build interoperability with our primary operational partners.**

28. The UK Government has always embraced international collaboration in this sector and will continue to do so. Our international engagement reflects our global approach: an unwavering commitment to European security, a leading contributor to NATO, a Permanent Member of the United Nations Security Council, strong intelligence relationships and a track record of successful international partnering. The UK is in an enviable position in the Combat Air sector thanks to historic investments, the Royal Air Force's reputation and track record in the air domain, and a world-class industrial base.

29. Effective international partnering and collaboration in the Combat Air sector offers the UK the best opportunity to deliver our military capability requirements while managing cost and maximising wider national policy and prosperity outcomes. Value for money in acquisition is heavily dependent on programme volume to offset upfront investment in research and development. Our approach to partnering will seek to achieve this, including through exports. The UK approach to future partnerships will seek to leverage the technological and industrial strengths of our partners to further drive down costs.



LiftSystem

Decades of research and development on Short Take-Off and Vertical Landing (STOVL) aircraft propulsion systems, from the 'flying bedstead' to the Pegasus engine on Harrier, helped secure the UK's status as a Tier 1 partner in the F-35 programme. Rolls-Royce exploited this Government and industry investment in Intellectual Property to develop the LiftSystem for the F-35B Lightning II, the world's first STOVL-capable supersonic aircraft.

Meteor: successful multinational collaboration

Meteor is a beyond-visual range air-to-air missile. It was developed through a highly successful, six-nation programme which is currently delivering game-changing air-to-air combat capability. A robust governance model was adopted at the outset. A UK-led Joint Project Office is empowered to drive the programme to cost and time, with a single contracting authority and single industrial leadership. Workshare is allocated with strict commercial targets and a single production line avoids duplication and inefficiency.



30. Our experience shows that the international market is increasingly based on Government-to-Government partnerships rather than industry-led sales. Partners are seeking to develop their own national capabilities and industrial base. They will rightly expect returns on their investment; from influence in requirements setting to achieving technological, industrial and economic goals.

31. Combat Air capabilities are a symbol of national ambition and intent, and there are many countries seeking to develop their own onshore manufacturing capabilities. The UK is keen to support indigenous capability development and encourage technological advancement of partners and allies. This is a critical component of the UK's contribution to global security.



Typhoon aircraft taking part in Exercise Bersama Lima 16

32. Interoperability is fundamental to the success of alliance and coalition operations. Future partnerships should therefore maximise interoperability, especially with the United States, wider NATO, European and an increasing range of global allies and partners.
33. To deliver future capabilities the UK will need to rapidly secure international partnerships for development and delivery. To do this we will:
 - a. ensure partnerships are based on shared and realistic defence requirements, rather than political opportunism and industrial protectionism;
 - b. share capability requirements, concepts and national technologies with key partners and allies to explore the feasibility of joint programmes;
 - c. ensure the partnering framework provides clear leadership, builds on the strengths of contributing nations and has as its primary purpose the need to deliver capability quickly with minimal bureaucracy and process;
 - d. complete a series of rapid feasibility studies within 12 months with a wide range of potential partners across the globe. These can be done bilaterally or multilaterally, building on the preferences of allies and existing structures (e.g. the NATO Eurofighter and Tornado Management Agency), to understand the potential for collaboration and the implications for our national choices and operational advantage; and
 - e. seek partners who share similar and complementary objectives.
34. There are of course risks; if badly conceived, collaboration can increase programme overheads, cause delay, increase cost and deliver sub-optimal capabilities. We will be transparent with partners to ensure the greatest degree of mutual understanding and compatibility.



Typhoon production line

Chapter 4

National Value in Combat Air

- The UK's future approach to Combat Air will be based on an HM Treasury Green Book compliant national value framework which enables genuine national choice and balances the values delivered by the sector.
- These values take account of the UK's National Security Objectives, the 2017 UK Industrial Strategy and wider economic prosperity.
- The approach will be at the heart of all major Combat Air investment and acquisition decisions. It is adaptable to the political, operational and international context, including our partners' requirements.
- These values are not binary choices and a successful outcome will require trade-offs to maximise the overall benefit to the UK.

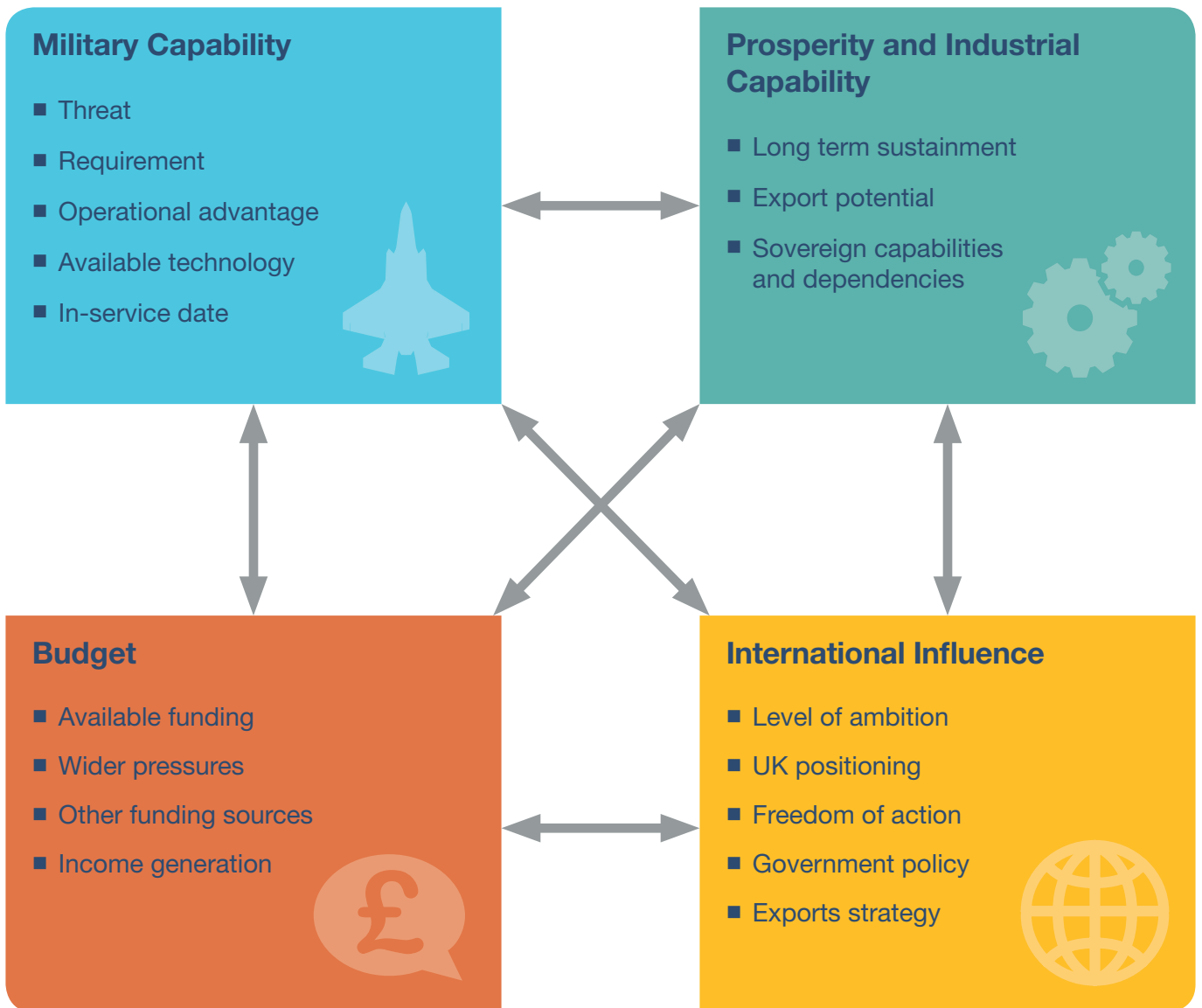
The UK Combat Air Sector:

- provides highly effective military capability and deterrence, thereby maintaining the security of UK airspace and our ability to create air superiority, enabling UK forces to support our global objectives;
- sustains high quality engineering and manufacturing jobs in clusters around the UK, both in the defence aerospace sector and adjacent sectors;
- delivers advanced technology and skills in the industrial base that have wider application and benefit in other sectors; and
- underpins our international influence and relationships with allies and partners generated by our global standing in the sector, the capabilities of the Royal Air Force and the UK industry that supports it.

35. The Ministry of Defence needs to consider cost, capability and programme goals in Combat Air alongside strategic national long-term objectives and outcomes. Failing to adopt this broad, balanced approach could result in programmes which prioritise sovereign capability requirements at the expense of prosperity and exports; or international partnering at the expense of pace and cost.
36. For the Combat Air sector, an approach is therefore required that defines and balances the broader values the UK wishes to deliver from the outset. This methodology will enable values to be traded where necessary to inform national decision-making and negotiations with international partners.
37. The National Value Framework supports the 2015 National Security Objectives (NSOs) and the objectives of the Government's Industrial Strategy. They are defined under the headings of: military capability (operational advantage and freedom of action), prosperity and industrial capability, and international influence. This framework is designed to be adaptable to the political, economic, operational and international context in which decisions are made.

- 38. The framework allows the Ministry of Defence to compare the relative benefits of a range of options from procuring 'off-the-shelf' to partnering with allies. When placed alongside detailed cost analysis it will enable us to determine relative value for money of the options and consider trade-offs.
- 39. This evolving approach to appraisal will support delivery of strategic objectives and will be developed so that it is compliant with key Government policies and conforms

to the methodology of the HM Treasury Green Book for objective evidence-based decision-making. The Ministry of Defence will work in partnership across Government to define the precise policy and strategy value inputs that will apply to future Combat Air programmes, including preparing detailed acquisition guidance in line with the HM Treasury Green book.



National Value Framework

A FRAMEWORK FOR NATIONAL VALUE IN COMBAT AIR

Military Capability

This value will measure the UK's assured ability to:

- Develop, acquire, certify, operate and sustain the current and future Combat Air capabilities necessary to meet UK national Defence policy objectives.
- Achieve and maintain a military edge over our adversaries.
- Operate our Combat Air capability in conjunction with allies and partners to support operational effectiveness and burden-sharing.
- Respond with agility to exploit opportunities and address threats in the future technological, operational and strategic environments.
- Maintain our ability to deploy Combat Air capabilities at the time and place of our choosing, including alongside allies and partners in the majority of circumstances.
- Maintain choice in our current and future Combat Air capability and acquisition, ensuring intelligent customer status in both national and collaborative programmes.

Prosperity and Industrial Capability

This value will assess the degree to which the UK can:

- Sustain investment in highly skilled, high value jobs throughout the Combat Air supply chain, including in the related wider defence and civil sectors, promoting prosperity.
- Contribute to the UK's underpinning Science, Technology, Engineering and Mathematics (STEM) skills base.
- Support the development of high-end technologies, tools, processes and infrastructure with application and benefit to adjacent sectors and the civil market.
- Drive affordability through international partnering, particularly to avoid unnecessary duplication, gain access to international expertise, share non-recurring expenditure and drive economies of scale.

International Influence

This value will measure the degree to which the UK can:

- Leverage wider UK economic, international and trade relationships in support of Global Britain.
- Secure effective and efficient partnerships based on compatible national interests.
- Maintain choice for the UK in our future acquisition and partnering options. Enabling the UK to maintain a balanced portfolio and to develop innovative and sustainable long-term global partnerships that recognise widespread aspirations to develop indigenous capability.
- Protect UK operational, technological and economic advantage.
- Maintain assured access to global supply chains and technology to support cost-effective capability development and acquisition.
- Secure wider strategic influence based on the unique nature of Combat Air capabilities and their impact on operational effectiveness and national credibility.



Chapter 5

A New Approach to Capability Delivery

40. In addition to the National Value Framework, the objectives defined in previous chapters demand a new approach to acquisition, commercial relationships and ways of working across industry, government and partners. This change is driven by the need to deliver capability quickly and cost-effectively. It requires commercial approaches that incentivise Government and industry to drive down cost, increase pace and performance and embrace innovation.



BAE Systems simulator

NIACE

The Northern Ireland Advanced Composites and Engineering facility demonstrates the benefits of Government, Academia and Industry working together. A partnership between Bombardier, Ulster University, Queen's University Belfast, Invest Northern Ireland and the Department for Business, Energy and Industrial Strategy has brought together engineering companies and knowledge providers to work on cutting edge Research and Development. The facility is open to use by any partner. Equipment on the site is available for all to use on a zero-profit basis. The output is utilised to support the rapidly-growing industrial base in Belfast and across the region.

Principles for effective acquisition and delivery

41. Effective and affordable Combat Air acquisition requires the Ministry of Defence to:
 - a. implement a governance and programme management approach that provides strong strategic leadership and delivers rapid decision-making to drive pace in delivery;
 - b. take an enterprise approach across Government and industry, based on greater transparency, aligned and simplified outcomes and a drive to continually improve productivity and cost-effectiveness. This approach will deliver strong and enduring commercial incentives that recognise the importance of sharing cost, benefit and risk;

- c. provide long-term commitment and financial stability to incentivise public and private investment in people and infrastructure;
- d. drive competition throughout the supply chain to improve performance and efficiency;
- e. recognise the importance of through-life costs and factor these into programme design;
- f. build on successful support solutions delivered by the UK Combat Air enterprise, taking advantage of the latest commercial and technological developments in aerospace and beyond to minimise through-life cost;
- g. take an evolutionary approach, retaining the best in-service technologies and sub-systems on future systems, and incrementally developing them through-life. This approach will reduce programme risk, improve industrial sustainability and reduce time and cost allowing for greater agility by addressing whole system upgrades in stages;
- h. develop bespoke mechanisms to incentivise export success and the recycling of revenue and commercial benefits to fund and de-risk future capability development; and

A Novel Approach to Defence Procurement: the Complex Weapons Portfolio Management Agreement

The Portfolio Management Agreement between the Ministry of Defence and MBDA secured UK freedom of action and operational advantage in the complex weapons sector, met the operational needs of all three armed services and saved an independently verified £1.2Bn from the equipment programme in its first seven years. This has been achieved through a centrally managed portfolio of weapons and its success depends on a long-term and transparent relationship between customer and supplier.

- i. recruit people with the behaviours and mind-set to take responsibility and collaborate across industry, Government, and our international partners.

These principles will be applied to all future Combat Air acquisition activities, ranging from support solutions to the procurement of major new capabilities, recognising that the circumstances and context of each activity will be different.

Academy of Skills and Knowledge

This education centre was created by BAE Systems with an investment of £15M. The academy trains up to 200 apprentices a year in critical skills. The facilities in the Academy are available to schools and universities. In its first year over 1000 local schoolchildren visited the Academy experiencing a Virtual Reality cave, a 3-D printing facility and a full-sized Hawk aircraft. The Academy, located on an Enterprise Zone near the Samlesbury manufacturing facility is acting as a hub to bring in new businesses with requirements for STEM graduates.

Chapter 6

Next Steps

To deliver this Strategy the Ministry of Defence will work with wider Government, industry and international partners in taking the steps laid out in this chapter.

42. The Ministry of Defence will continue to **invest in upgrading Typhoon capability**, particularly in sensors and weapons systems to maintain the system's combat effectiveness and competitiveness. The best of these technologies will be carried forward on to next generation systems.
43. Under the Future Combat Air System Technology Initiative, the Ministry of Defence will **initiate technology demonstrations** co-funded with industry to de-risk next generation technologies and ensure the UK has capability across Government and industry.
44. To define and deliver the future capabilities required when early models of Typhoon leave Royal Air Force service in the late 2030s, the Ministry of Defence will immediately **initiate the UK's Combat Air capability acquisition programme**. Working across Government and with industry and international partners, the Ministry of Defence will:
 - a. deliver a strategic outline business case, including high level military requirements, by the end of 2018;
 - b. accelerate and deepen engagement with international partners to create the best opportunities to deliver next generation Combat Air capability. An initial assessment of international collaboration options will be delivered by the summer of 2019;
 - c. further refine operational requirements by the end of 2019 to inform capability choices and partnering discussions;
45. Completing this programme of work over the course of 2018 and 2019 will enable the Ministry of Defence to:
 - a. confirm early decisions for capability acquisition by the end of 2020 (covering the class of capability, partnering approach, cost and delivery schedule); and
 - b. confirm final investment decisions by 2025 to ensure delivery of an Initial Operating Capability by 2035.
46. The Ministry of Defence will **establish an acquisition team** in its Head Office to provide departmental leadership, drive delivery of the Strategy, lead international engagement and the capability acquisition programme.
47. Working with the Department for Business, Energy and Industrial Strategy and industry partners, the Ministry of Defence will **drive transformation in the industrial enterprise**. This will build on the work done in the Future Combat Air System Technology Initiative, and incentivise the involvement of the wider UK skills base.

48. To exploit the significant future global demand for systems to replace current 4th generation platforms, the UK will work with partners to **generate first-mover advantage**.
49. The Ministry of Defence will work with the Foreign and Commonwealth Office, Department for International Trade and the overseas network to **create the best opportunities for international cooperation**. This will include industrial, economic, military and academic opportunities that deliver mutual benefits to international partners.
50. The Ministry of Defence will **define areas that are critical to operational advantage and freedom of action** to inform long-term industry and academic investment as well as international workshare and partnering discussions.
51. The Ministry of Defence and the Department for Business, Energy and Industrial Strategy will **launch a Combat Air Skills Index** to monitor the health of industrial and government skills, capability and capacity critical to the delivery of our national objectives. This will be developed with input from industry partners and used to assess the success of interventions such as the Future Combat Air System Technology Initiative.
52. The Ministry of Defence, industry and appropriate other government departments will **implement a governance construct** for delivering this Strategy and future acquisition programmes. This will provide strong strategic leadership and deliver rapid and delegated decision-making to drive pace in delivery.
53. The Ministry of Defence, the Department for Business, Energy and Industrial Strategy and HM Treasury will jointly **assess the economic impact of our choices**. This will include the benefits of Combat Air activity for the economy including research and development, training and skills, and the benefits to wider industry. This will be used to inform the assessment of options.
54. The Ministry of Defence will continue to develop the National Value Framework, compliant with the HM Treasury Green Book, which will be used to inform decisions on future acquisition programmes and next tranches of F-35.
55. The Ministry of Defence will take a strategic approach to wider international and industrial partnerships and opportunities which contribute to maintaining and developing skills and capacity in industry. Specifically, UK Government and industry will **take a national campaign approach to winning work on the F-35 Maintenance, Repair, Overhaul and Upgrade Phase 2 competition**.
56. The Secretary of State for Defence will **report annually to Parliament** on progress in implementing the Strategy.

Disclaimers

The figures in this report are primarily based on RAND-Europe analysis using industry survey data provided for the purposes of this study and ONS data, augmented by information from literature review and interviews with government stakeholders. While the underlying industry data only covers ten companies with a major presence in the UK Combat Air sector, the study team believes that it captures the majority of the UK combat air industrial base and thus provides a useful benchmark for analysis of the sector's contribution to prosperity.

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A vision for the future of UK Combat Air

