



Ministry
of Defence

Joint Doctrine Publication 0-30
UK Air and Space Power

Second Edition

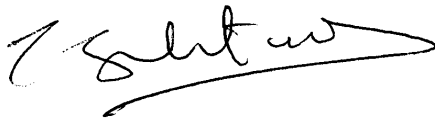


Development, Concepts and Doctrine Centre

Joint Doctrine Publication 0-30 UK Air and Space Power

Joint Doctrine Publication 0-30 (JDP 0-30) (2nd Edition),
dated December 2017,

is promulgated
as directed by the Chiefs of Staff



Director Concepts and Doctrine

Conditions of release

This publication is UK Ministry of Defence Crown copyright. Material and information contained in this publication may be reproduced, stored in a retrieval system and transmitted for UK Government and MOD use only, except where authority for use by other organisations or individuals has been authorised by a Patent Officer of the Defence Intellectual Property Rights.

Authorisation

The Development, Concepts and Doctrine Centre (DCDC) is responsible for publishing strategic trends, joint concepts and doctrine. If you wish to quote our publications as reference material in other work, you should confirm with our editors whether the particular publication and amendment state remains authoritative. We welcome your comments on factual accuracy or amendment proposals. Please send them to:

DCDC, Ministry of Defence Shrivenham, Swindon, Wiltshire, SN6 8RF

E-mail: DCDC-DocEds@mod.gov.uk

Telephone: 01793 31 4216/4217/4220

Copyright

This publication is UK Ministry of Defence © Crown copyright (2017) including all images (unless otherwise stated).

If contacting Defence Intellectual Property Rights for authority to release outside of the UK Government and MOD, the Patent Officer should be informed of any third party copyright within the publication.

Crown copyright and Merchandise Licensing, Defence Intellectual Property rights, Central Legal Services, MOD Abbeywood South, Poplar 2 #2214, Bristol, BS34 8JH

Email: DIPR-CC@mod.gov.uk

Distribution

Distributing Joint Doctrine Publication (JDP) 0-30 (2nd Edition) is managed by the Forms and Publications Section, LCSLS Headquarters and Operations Centre, C16 Site, Ploughley Road, Arcott, Bicester, OX25 1LP. All of our other publications, including a regularly updated DCDC Publications Disk, can also be demanded from the LCSLS Operations Centre.

LLCSLS Help Desk: 01869 256197

Military Network: 94240 2197

Our publications are available to view and download on the Defence Intranet (RLI) at: <http://defenceintranet.diif.r.mil.uk/Organisations/Orgs/JFC/Organisations/Orgs/DCDC>

This publication is also available on the Internet at: www.gov.uk/mod/dcdc

Foreword

As the Royal Air Force enters its second century, we celebrate our nation's success in leading the development of air power but also recognise the challenges ahead. The contemporary strategic environment is characterised by instability, unpredictability and blurring of the boundaries between war and peace. The rules-based international order, upon which our stability and prosperity is based, is increasingly challenged whilst the extraordinarily rapid pace of technological change in the information space is transforming the character of conflict. Potential adversaries are growing in capability and confidence, challenging our freedom to operate through a proliferation of potent counter-air and space systems and malicious cyber activities. Gaining and maintaining advantage in the air and space domains, alongside our allies and partners, remains crucial to the freedom of action of the joint force. In such a complex operating environment, creativity, adaptability and resilience are in as high demand as ever.

The generation of combat, intelligence, surveillance and reconnaissance and mobility aircraft now entering service will transform how we fight and will be the bridge to the introduction of even more transformational air and space technologies. In realising their potential we must exploit opportunities to enhance integration – military and non-military, at home and overseas – as well as optimising cross-domain integration to contribute to joint action. It is crucial too that we remain committed to our leading role in international relationships, particularly NATO as the cornerstone of European security. The profile of the space domain is growing as our dependence upon it increases and the boundaries between air and space become less distinct. Space has become more accessible and affordable not only to us but also to our potential adversaries, and understanding the domain now needs to be a business for all, not just for a small group of specialists. Of equal importance in maintaining an edge will be the ability to manage vast amounts of information and make decisions more quickly and accurately. In this rapidly changing world, it will ultimately be our people and the superiority of the decisions they make that will determine our continued decisive edge into the future.

Drawing on historical lessons and highlighting current and future challenges, Joint Doctrine Publication (JDP) 0-30, *UK Air and Space Power* describes the utility and employment of air and space power in the context of joint and multi-national operations. I encourage you to use it to develop your approach to operations in the air and space domains, whatever part you play.

Chief of the Air Staff

Preface

Purpose

1. Joint Doctrine Publication (JDP) 0-30, *UK Air and Space Power* is the keystone air and space domain publication. Whilst JDP 0-01, *UK Defence Doctrine* provides the broad principles and philosophy underpinning the use of UK Armed Forces, JDP 0-30 is focussed specifically on UK air and space power. It brings together higher-level doctrine, Government policy and enduring air and space power knowledge and experience to provide a basis for understanding the utility of the air and space domains. It highlights the strengths and recognises the limitations of air and space power and explores their interdependence with the other elements of national and military power, as well as multinational and private sector partners. It also considers those factors which, in broad terms, enable the effective employment of air and space power.

Context

2. This second edition of JDP 0-30 continues the joint theme that was initiated in the first edition. In support of this joint approach, it aims to generate broad consistency with its sister publications JDP 0-10, *UK Maritime Power* and JDP 0-20, *UK Land Power*, which has led to the development of a revised common structure.

Audience

3. This edition of JDP 0-30 is a simple and concise explanation of air and space power, which seeks to inform a wide audience. It is designed to highlight the strategic utility of air and space power, and their contribution to national power. JDP 0-30 should be of value to joint commanders and staffs, the single Services, the broader defence community and other government departments, as well as UK partners and allies.

Structure

4. JDP 0-30 is divided into two parts, each consisting of four chapters. Part 1 covers UK air power and Part 2 covers UK space power.

Part 1 – UK air power

- a. **Chapter 1 – An introduction to UK air power.** Chapter 1 provides an overview of UK air power, outlining its enduring utility in a complex and

uncertain operating environment. It introduces the attributes and roles, and provides a definition of UK air power.

- b. **Chapter 2 – Air power in context.** Chapter 2 discusses the aspects of the air domain and provides an overview of the context in which UK air power is employed. It describes the principal factors that shape the contemporary operating environment.
- c. **Chapter 3 – The foundations of air power.** Chapter 3 provides more detail on the attributes and roles of air power, whilst also highlighting challenges. It provides an overview of the conceptual, moral and physical components of fighting power.
- d. **Chapter 4 – The employment of air power.** Chapter 4 considers the application of UK air power in the context of a joint and full spectrum approach and highlights how it integrates with other elements of military power. It provides an overview of key air power enablers and highlights air power's contribution to Defence Tasks.

Part 2 – UK space power

- a. **Chapter 5 – An introduction to UK space power.** Chapter 5 provides an overview of UK space power, outlining its increasing importance and utility in the contemporary operating environment. It also introduces the attributes and roles, and provides a definition of UK space power.
- b. **Chapter 6 – Space power in context.** Chapter 6 outlines the factors that shape the space domain. It provides an overview of the global and national context within which UK space power is employed.
- c. **Chapter 7 – The foundations of space power.** Chapter 7 provides an overview of the attributes and roles of space power, and highlights which UK space capabilities contribute to the various missions within the separate roles.
- d. **Chapter 8 – The employment of space power.** Chapter 8 considers how we apply space power within a joint, multinational and interagency environment as part of a full spectrum approach. It also provides an overview of how we coordinate military space capabilities at the national and multinational level.

Linkages

5. JDP 0-30, *UK Air and Space Power* is the keystone air and space domain doctrine publication within the joint doctrine architecture, sitting below JDP 0-01, *UK Defence Doctrine* and alongside other joint doctrine; JDP 0-10, *UK Maritime Power* and JDP 0-20, *UK Land Power*. It is also founded upon an understanding of current policy, in particular the *National Security Strategy and Strategic Defence and Security Review 2015*, the *UK National Space Policy* and the *UK National Space Security Policy*. JDP 0-30 is coherent with North Atlantic Treaty Organization Allied Joint Publication (AJP)-3.3, *Allied Joint Doctrine for Air and Space Operations*. While reflecting the joint context, it is also coherent with the Royal Air Force's capstone doctrine, Air Publication (AP) 3002, *Air and Space Warfare*, which provides more detail of air and space power.

Contents

Foreword	iii
Abstract	v
Chapter 1 – An introduction to UK air power	1
Chapter 2 – Air power in context	9
Chapter 3 – The foundations of air power	23
Chapter 4 – The employment of air power	47
Chapter 5 – An introduction to UK space power	69
Chapter 6 – Space power in context	77
Chapter 7 – The foundations of space power	89
Chapter 8 – The employment of space power	109
Lexicon	119





ROYAL AIR FORCE


UKaid
from the British people



Part 1 – UK air power



Chapter 1

An introduction to UK air power

Chapter 1 provides an overview of UK air power, outlining its enduring utility in a complex and uncertain operating environment. It introduces the attributes, roles and provides a definition of UK air power.

1

“
If we **lose the war in the air, we lose
the war** and we lose it quickly.
”

Field Marshal Bernard Montgomery

Chapter 1 – An introduction to UK air power

Introduction

1.1. The UK Government uses three instruments of power in pursuit of national policy goals; underpinned by information, these are diplomatic, economic and military instruments.¹ UK maritime, land, air, space and cyber power provide the Government with options to use the military instrument of national power.² Since its inception, air power has made a vital contribution to the UK military instrument, helping maintain the freedom of the nation and projecting national influence when called upon.

1.2. In the UK, the Royal Air Force (RAF) has the conceptual lead for aerial warfare, so the structure of the UK Armed Forces rightly focuses the generation and employment of air power around the RAF. However, the Fleet Air Arm of the Royal Navy and aviation elements of the British Army also contribute to the delivery of UK air power. All are active domestically and globally year round, protecting UK national interests at home and overseas.

The enduring utility of air power

1.3. By the end of World War I, air power had made an impact across all forms of warfare. The enduring attributes of height, speed and reach had been established and the majority of air power roles had been employed. By World War II, no military activity could overlook the significance of air power. When properly targeted and coordinated, it proved influential in all theatres of war. During, and post World War II, the development of air power accelerated dramatically, with investment in airframe, engine, sensor and weapon technologies, enabling the delivery of significant influence across all war fighting domains.

1.4. Such hard earned experience in the use of air power has confirmed the fundamental characteristics of height, speed, reach, agility and ubiquity. **Height** enables the observation and domination of activities in other domains; **speed** enables the rapid and responsive projection of power; **reach** enables adversaries to

1 See Joint Doctrine Publication (JDP) 0-01, *UK Defence Doctrine* for a full explanation of national power, national security, the national interest and national strategy.

2 UK air power is also applicable to the diplomatic and economic instruments of power, through the use of airports and airlines. Although civilian elements are covered, the focus of this publication is on the military aspects of UK air power.

be influenced, regardless of their location. These three elements, combined with the **agility** of multi-role air capabilities, provide air power with **ubiquity**, as threats can be posed or countered across a wide area, wherever and whenever it is required.

1.5. Four core roles of air power have endured since the earliest days of military aviation and provide the basis for understanding the air as an operating domain. The exploitation of these roles and attributes form the foundation of UK air power's broad utility as an instrument of national power.

1

The four roles of air power.

- **Control of the air** secures our freedom of action within the air environment.
- **Intelligence, surveillance and reconnaissance** informs the development of understanding across all environments.
- **Attack** can coerce and influence actors into changing or maintaining behaviour.
- **Air mobility** enables movement, manoeuvre and sustainment.



A Royal Air Force Typhoon during Exercise GRIFFIN STRIKE 2016

Influence and power from the air

1.6. Political, military and economic credibility, together with a coherent diplomatic agenda, play a large part in the UK's ability to influence.³ Power is the capacity to influence the behaviour of people or the course of events and underpins the ability to influence. Although skilful diplomacy across multiple government departments helps to fuse all elements of power through smart power, it is broadly sub-divided into hard and soft variants.⁴

- a. **Hard power** is the threat or use of coercion or a physical effect to achieve influence. In the case of air power, this could be achieved through a precision guided weapon delivered by a combat aircraft employed in the attack role.
- b. **Soft power** is the ability to persuade or encourage others to adopt an alternative approach without recourse to hard power. This could be achieved by a humanitarian aid delivery by an aircraft employed in the air mobility role.

1.7. Consequently, the key to understanding air power is recognising its ability to create influence, through both hard and soft power. Air power is defined as: using air capabilities to influence the behaviour of actors and the course of events.⁵

1.8. A variety of military options can be used to influence the behaviour of actors and the course of events, and although air power can be used independently, it primarily seeks to create effects and exert an influence in other domains. It is therefore inherently joint, so the desired effects must be synchronised across the domains, not just the air domain. Similarly, operations in the maritime, land, space and cyber domains all have the ability to influence events in the air domain.

Adapting to the context

1.9. The strategic context within which UK air power is employed is becoming more unstable, complex and uncertain. It is characterised by a state of competition between a progressively wide range of actors, both state and non-state, which has blurred the traditional distinctions between war and peace. The conventional, physical fighting domains of maritime, land and air, largely enabled by the space domain, have been joined by the highly contested cyber domain, all underpinned by the pervasiveness of information. Overseas and homeland threats have also merged.

³ JDP 04, *Understanding and Decision-making*.

⁴ JDP 0-01, *UK Defence Doctrine*.

⁵ This definition remains unaltered from the first edition of JDP 0-30, *UK Air and Space Doctrine*.

“
The **strategic context** within which UK air power is employed is becoming **more unstable, complex and uncertain**.
”

1.10. It is within this uncertain, changing context that air power offers flexible, timely, scalable and responsive options to the UK Government in support of national security objectives. It contributes to a wide variety of tasks, ranging from high-end war fighting, through to deterrence and Defence Engagement. Within these tasks sit a broad range of activities, including counter terrorism, delivering humanitarian assistance and providing aid to the civil authorities.

1.11. Agile, adaptable and capable, UK air power therefore has significant utility as it offers a tailored response to evolving circumstances and an array of capabilities that can rapidly transition between tasks. To fulfil these tasks, UK air capabilities are held at the appropriate readiness to be applied at the right time and place, both at home and overseas.



A Royal Navy Merlin Mk2 helicopter picking up vital aid equipment in support of UK humanitarian assistance operations in Sierra Leone

Key points

- Air power is defined as: the ability to use air capabilities in and from the air, to influence the behaviour of actors and the course of events.
- UK air power, along with maritime, land, space and cyber power, form the interdependent levers of the military instrument of national power.
- UK air power is active domestically and globally year round, protecting UK national interests at home and overseas.
- Although air power can be used independently of the other operating environments, it seeks to create effects and exert influence within them.
- Conversely, maritime, land, space and cyber forces all have the ability to influence events in the air environment.
- The strategic context within which UK air power is employed is becoming more unstable, complex and uncertain.
- Agile, adaptable and capable UK air power has significant utility, as it offers a tailored response to evolving circumstances and an array of capabilities.



Air power in context

Chapter 2 outlines the factors that shape the air environment and provides an overview of the context in which UK air power is employed. It also describes the principal factors that shape the contemporary operating environment.

Section 1 – Aspects of the air environment.	11
Section 2 – The global and national context	14
Section 3 – The contemporary operating environment	17

//

The **rules of war have changed**, as there is a **blurring of the lines** between war and peace, and **non-military means** of achieving military and strategic goals **has grown** and, in many cases, **exceeded** the power of **weapons** in their effectiveness.

//

General Gerasimov,
Chief of the General Staff,
Russian Armed Forces

Chapter 2 – Air power in context

2.1. Air power is truly global in nature as it theoretically enables access to any point on Earth, be it over land or sea. To maximise the utility of air power, the key aspects of the air domain, the surrounding context and the contemporary operating environment must all be clearly understood.

Section 1 – Aspects of the air environment

Physical aspects

2.2. The air environment is an unforgiving one, so aircraft are designed to meet the challenges of operating at a variety of altitudes, temperature extremes and speed ranges. The physics and aerodynamic principles associated with the air environment also complicate the design process for aircraft.

2.3. Most manned aircraft are able to withstand or avoid the extreme weather that can occur in the air but unmanned aircraft are more susceptible to such conditions.⁶ The laws of physics dictates that the performance of some aircraft and weapon sensors are also adversely affected by extremes of poor weather. However, the versatility offered by an array of sensors across the electromagnetic spectrum (EMS) provides an acceptable level of resilience and enables agility.



A Merlin Mk3 helicopter with the Commando Helicopter Force after conducting an Arctic training sortie

.....
6 Unmanned aircraft is an umbrella term, which includes the subset remotely piloted aircraft, which requires a fully qualified pilot to operate. See Joint Doctrine Publication (JDP) 0-30.2, *Unmanned Aircraft Systems* for more details.

Political aspects

2.4. Air power offers policy-makers an agile, timely and focussed capability that can be highly effective in resolving or averting a developing crisis. It can also potentially negate the requirement to deploy a larger force over a broader timescale by land or sea. By minimising or removing the requirement for land forces, air power can make it easier to commit in politically ambiguous circumstances. Its speed, mobility and precision combine to make it an attractive element of the military instrument of national power. Speed is a particularly attractive feature, as it enables air power to rapidly accomplish political and military objectives, either by striking at an adversary's vulnerabilities, or by delivering humanitarian aid in support of an ally.

2.5. Air power's agility also means the scale and scope of operations can be rapidly escalated or de-escalated in response to a change in political guidance or political strategic objectives, from air policing at one end of the spectrum to full-scale war fighting at the other.⁷ It can also be an effective means of achieving objectives by avoiding the military and political liabilities which can arise from an extended presence in a foreign country. Consequently, since the end of the Cold War, air power has played a major role in state responses to conflict.

Legal aspects

2.6. Although the attributes of air power present the ability to reach any point on Earth, desired air power effects can be constrained by legal aspects, since each state has sovereignty over the airspace above its territory. Therefore, in the absence of another legal basis,⁸ access and overflight of another state requires their permission. The UK will always operate in accordance with its legal obligations including the Law of Armed Conflict when applicable.⁹

2.7. Strict adherence to the LOAC and the application of supporting operational policies is essential to ensure the lawful use of force via air power in an armed conflict. A well-established and comprehensive targeting process will be adhered to,¹⁰ and a managed audit trail records actions and decisions, to help demonstrate that our activities were legal. A disciplined approach to the lawful application of force and the recording of those decisions enable UK Armed Forces and the Government to address

7 The mere deployment of combat aircraft to a location in close proximity to a potential adversary can achieve influence, such as deterrence.

8 Such as a United Nations (UN) Security Council Resolution or 'action in self-defence', in accordance with Article 51 of the *Charter of the United Nations*.

9 See Joint Services Publication (JSP) 383, *Joint Service Manual of the Law of Armed Conflict* and the Attorney General's speech at the International Institute for Strategic Studies, 11 January 2017, available at: <https://www.gov.uk/government/speeches/attorney-generals-speech-at-the-international-institute-for-strategic-studies>.

10 JSP 900, *UK Targeting Policy*.

By minimising or removing the requirement for land forces, air power can make it easier to commit in politically ambiguous circumstances.

accusations of alleged wrong-doing or disproportionate collateral damage, whether they arise from enemy propaganda, media challenge or public misconception.

Economic aspects

2.8. Freedom of navigation in the air environment enables international trade and helps to secure international safety.¹¹ As our national security depends on our economic security, the ability to influence and shape what happens in the air environment is of fundamental importance to not just our national security but also our continued prosperity.¹² As an island nation, the UK relies on its air lines of communication for this prosperity, just as it does its sea lines of communication. The air environment must therefore be secured to allow the freedom of movement, which bolsters the economy and supports the prosperity of the nation.

2.9. Although this publication focuses on the military elements of air power, broader UK air power includes aspects such as civil air capacity and capability. For example, UK international airports, airlines and freight carriers and the ability to control and support international air traffic, through the existence of the Civil Aviation Authority and civilian air traffic control, are all aspects of broader UK air power which bolsters the UK economy, ultimately reinforcing national security.

2



flickr.com

Global air and sea routes

11 Chief of the Defence Staff speech at the Royal United Services Institute, 21 December 2016.

12 *The National Security Strategy and the Strategic Defence and Security Review 2015 (NSS/SDSR 2015)*.

Section 2 – The global and national context

2

Global alliances

2.10. The globalised nature of international security encourages the UK to form alliances and partnerships that help ensure security and protect national interests. Such relationships are increasingly important because the complex nature of potential threats often requires a multifaceted response. Interoperability between air forces also enhances alliances and coalitions, generating greater combat mass, resilience and access to an array of capabilities.

2.11. A broader multinational and multi-agency response involving many actors, including allies, international organisations and non-governmental organisations, can therefore provide a range of options that most nations could not generate independently. This could include unique capabilities, specific skillsets, or help by providing the required mass for favourable force ratios. Participating in multinational operations could also increase perceptions of legitimacy and increase international influence. Maintaining an alliance or coalition cohesion is often a strategic priority in any multinational operation.

2.12. Although a multinational approach can create even greater opportunities and capabilities, it can also generate frictions, especially where national objectives or policy freedoms differ. Developing coherence in areas such as risk and priorities in an alliance can be challenging, but all efforts must be made to overcome these as an adversary may seek to exploit any potential differences.¹³



NATO is the cornerstone of UK defence

2.13. The North Atlantic Treaty Organization (NATO) is the cornerstone of UK defence on the global scale and acts as the principal framework for UK operations. Not only is NATO our primary guarantor of security, but recent air operations in Afghanistan, Iraq, Libya and Syria demonstrate that it can act as the core of wider partnerships outside its traditional area of interest.¹⁴ UK air power has also played a key role in NATO operations in Eastern Europe, designed to deter Russia.

¹³ JDP 01, *UK Joint Operations Doctrine*.

¹⁴ Such as the International Security Assistance Force (ISAF) in Afghanistan or partners in the Middle East joining the fight against Daesh in Iraq and Syria.

Defence Engagement

2.14. Our dependence on multinational cooperation means we must take every opportunity to promote interoperability and engage with a broad range of potential partners. These range from the most technologically sophisticated air forces to less familiar and capable but potentially likely partners. As part of an integrated, cross-government approach to Defence Engagement,¹⁵ both the Royal Air Force (RAF) and the Air arms of the other single Services regularly conduct live, virtual and constructive multinational exercises, and participate in overseas exchange and Defence attaché programmes. Defence Engagement also supports UK prosperity and the Global Britain approach.¹⁶

The UK National Security Strategy

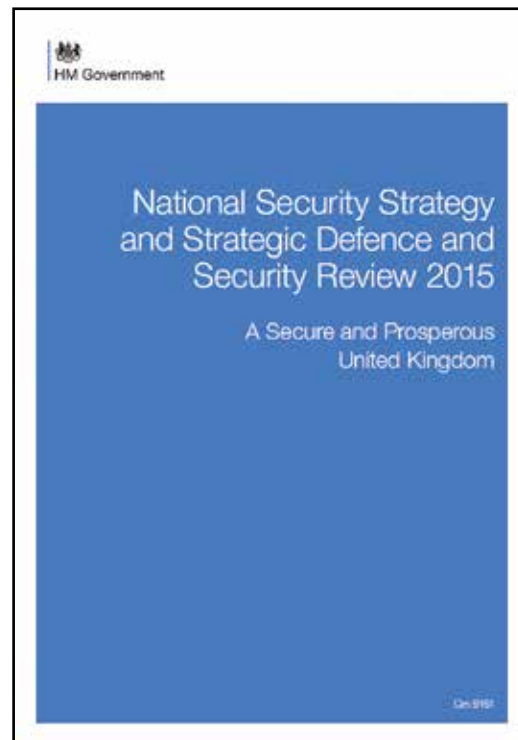
2.15. The *National Security Strategy and Strategic Defence and Security Review 2015* (NSS/SDSR 15) provides a national vision of a 'secure and prosperous United Kingdom, with global reach and influence'. This vision is supported by three national security objectives (NSO), which emphasise the requirement to protect the UK population and the economy.

- a. NSO 1: Protect our people – at home, in our Overseas Territories and abroad, and protect our territory, economic security, infrastructure and way of life.
- b. NSO 2: Project our global influence – reducing the likelihood of threats materialising and affecting the UK, or interests and those of our allies and partners.
- c. NSO 3: Promote our prosperity – seizing opportunities, harnessing innovation to strengthen our national security and working with industry to ensure we have the capabilities we need.

2.16. The fundamental purpose of UK air power is to support these NSOs, as part of a full spectrum approach, using all instruments of national power, to help **protect**, **project** and **promote**.

¹⁵ See Joint Doctrine Note (JDN) 1/15, *Defence Engagement* for more details.

¹⁶ Air power's contribution to Defence Engagement is covered in more detail in Chapter 4, Section 4.



2.12. **Protect.** UK air power has the capability to protect the UK and its Overseas Territories from attack, particularly from the air but also from other domains. The RAF is responsible for protecting UK airspace and stands ready to intercept rogue aircraft on a permanent basis.¹⁷ Delivering this capability requires an integrated air defence system, including the necessary aircraft, ground based systems, sensors, command and control capabilities, and associated infrastructure.¹⁸

2.13. **Project.** Air power contributes to the UK's global influence by projecting power rapidly and decisively, to prevent conflict and threats from materialising, either directly from the UK or from alternative land or sea basing options overseas. Air power is often the most rapid and responsive military lever available, providing the quickest way to exert influence. Rapidly projecting such power can help manage developing crises or ultimately include the ability to defeat or destroy adversary capabilities.

Operation ODYSSEY DAWN

At 0300 hours on Friday 18 March 2011, UK forces were directed to act fast to get an operation in Libya underway. By 0800 hours, the RAF declared readiness to attack key regime air defence nodes in Libya, with four Tornado GR4 combat aircraft, equipped with Stormshadow cruise missiles, in support of military strategic objectives. The Prime Minister granted approval for the mission at 2000 hours on Saturday 19 March and the aircraft departed the UK at midnight. Tankers provided air-to-air refuelling for the attack aircraft and intelligence, surveillance and reconnaissance (ISR) aircraft acted as their 'eyes and ears'.

The success of the 7½ hour mission provided a demonstration of air power's reach and responsiveness. It was the longest attack mission since the 'Black Buck' raids in the Falkland Islands conflict and the first flown from the UK since World War II. It paved the way for ten subsequent missions that destroyed other key command and control targets. Most importantly, in terms of influence and messaging, in less than 18 hours, the RAF had converted a political instruction into tangible action, towards a desired strategic end-state.

.....
¹⁷ NSS/SDSR 2015.

¹⁸ This capability also has a significant reliance on space capabilities and services.

2.14. **Promote.** UK air power is used to promote UK security and prosperity by engaging overseas, outside of core alliances such as NATO. For example, the Ministry of Defence provides mentoring, advice and training to partner air forces, helping them build the capacity to operate more effectively. This also supports general deterrence by providing a credible capability to potential adversaries. Persistent engagement overseas demonstrates a high level of commitment and contributes to conflict prevention by fostering mutual understanding through military-to-military contacts.



An RAF pilot mentoring an Afghan trainee pilot

Section 3 – The contemporary operating environment

2.17. We must understand the operating environment to maintain awareness and minimise surprise, whilst acknowledging the dynamic and unpredictable nature of events. Whilst individual conflicts will be unique, the contemporary operating environment exhibits a number of common features. These are:

- the pervasiveness of information;
- the growing importance of the cyber domain;
- rapid technological changes; and
- evolving tactics and strategies.

The pervasiveness of information

2.18. The increased availability and flow of information, and the requirement to rapidly process such information, complicates conflict. The connectivity, speed and data-sharing ability associated with globalisation and the information revolution enables the rapid and broad communication of messages and ideas through the virtual dimension. Relatively open access to the virtual dimension and the technology that enables it means that our adversaries can increasingly develop and exploit recruitment, propaganda and targeting opportunities, while promoting their own narratives.

2.19. Such rapid access to information means the effects of military power, good or bad, are not only visible to those directly affected but also to global audiences. The

effects of our actions could be interpreted in different ways, leading to the risk of misinformation. Rogue actors could use disinformation to present military activity in a skewed manner, to magnify, mitigate or alter the understanding of facts. This is of critical importance because our key audiences could judge whether our action is legitimate and whether it achieves its political objectives. The pervasiveness of information in the contemporary operating environment therefore means that the impact of military activity can have more immediate and potentially wide-ranging consequences than it had previously.

The growing importance of the cyber domain

2.20. The cyber domain is now routinely used to plan and execute military operations. Adversaries probe our networks and systems looking for vulnerabilities and intelligence to gain advantage. The effect of a cyber attack may vary depending on the intent and nature of the payload; although the majority are created and actioned in the virtual dimension, an attack may result in a physical effect.¹⁹ We must therefore ensure that our air capabilities are protected against cyber attack, while remaining capable of planning and executing operations with reduced or denied access to cyber capabilities.

2



Defending against cyber attacks is crucial to ensuring the effectiveness of our air capabilities

¹⁹ See the *UK Cyber Primer* for more information.



Unmanned aircraft are becoming more common in our skies

Rapid technological changes

2.21. The increasing proliferation of commercially available technology has the potential to increase the capability and effectiveness of our adversaries. Secure communications, surveillance systems and unmanned aircraft are now more affordable and can be easily acquired and improvised to perform a variety of functions, including crudely-targeted kinetic attacks.²⁰

2.22. Surface-to-air missile technology has advanced rapidly and the proliferation of such systems is spreading, particularly those developed in Russia and China. Some have significant lethal engagement ranges and can travel at hypersonic speeds, therefore able to threaten aircraft previously viewed as being beyond the range of adversaries. Such capabilities offer potential adversaries with an option to adopt anti-access and area denial (A2AD)²¹ strategies, which could significantly impact the ability to gain control of the air, due to the requirement to operate in a contested, degraded and operationally-limited domain. We must continue to develop counters to such threats to ensure control of the air and freedom of manoeuvre.²²

²⁰ Daesh have conducted crudely-targeted kinetic attacks using unmanned aircraft in Iraq and Syria.

²¹ Anti access capabilities are those capabilities, usually long range, which are designed to prevent an adversary from entering an operational area. Area-denial capabilities are those capabilities, usually of shorter range, which are designed not to keep the adversary out but to limit its freedom of action within the operational area. Together, they are referred to as anti-access and area denial (A2AD).

²² Air Publication (AP) 3002, *Air and Space Warfare*, Chapter 4.

Evolving tactics and strategies

2.23. The concept of hybrid warfare²³ is not a new one, but it is being increasingly employed. Potential adversaries have demonstrated the will and capability to undermine Western operational capability and legitimacy by blending conventional and unconventional forms of conflict, using both attributable and non-attributable methods. These methods use the physical and virtual dimensions, with or without the employment of conventional military forces, such as air power. It can be applied in ways that remain below Western military response thresholds, presenting a dilemma on how states should respond. The use of air power is therefore one capability option, which will be synchronised within a full spectrum of capabilities in any response to such activities.



Our Armed Forces act as part of a full spectrum of government capabilities

.....
23 A form of warfare combining conventional and unconventional military and non-military actions to achieve a specific goal.

Key points

- Air power is truly global in nature, as it theoretically enables access to any point on Earth, be it over land or sea.
- Air power offers policy-makers an agile, timely and focussed capability that can be highly effective in resolving or averting a developing crisis.
- As an island nation, the UK relies on its air lines of communication for its prosperity, just as it does its sea lines of communication.
- A broad multinational and multi-agency response involving allies, can provide a wide range of air power options that most nations could not generate independently.
- The North Atlantic Treaty Organization is the cornerstone of UK defence on the global scale and acts as the principal framework for UK operations.
- The fundamental purpose of UK air power is to support the three national security objectives, to help protect, project and promote.
- The use of air power is one capability option, which will be synchronised within a full spectrum of capabilities in any action.



Chapter 3

The foundations of air power

Chapter 3 provides detail on the attributes and roles of air power. It also provides an overview of the conceptual, moral and physical components of fighting power.

Section 1 – The attributes of air power	25
Section 2 – The roles of air power.	27
Section 3 – Fighting power.	43

//
Once **command** of the air is obtained,
the war becomes a **conflict between**
a **seeing host** and one that is **blind**.
//

H.G. Wells

Chapter 3 – The foundations of air power

Section 1 – The attributes of air power

3.1. The unique characteristics of the air environment provide air power with different strengths and weaknesses from maritime and land power. Many of these characteristics are complementary, which is why joint operations, when properly synchronised and executed, can be so effective. However, before a joint approach can be implemented, the fundamentals of what makes the air environment so different must be understood and this begins with understanding the associated attributes. The attributes of air power are:

- height;
- speed;
- reach;
- agility; and
- ubiquity.

3.2. **Height.** The air environment overlays both the land and maritime environments and offers those that operate within it the opportunity to exploit the vertical dimension. The advantage of height is an enduring military reality, as it allows us to observe and control activities in the maritime and land environments, offering significant strategic and operational utility. At the tactical level, height can put aircraft out of the vertical range of many surface threats and affords the ability to manoeuvre in three dimensions, helping to enhance survivability.

3.3. **Speed.** The speed of aircraft enables air power to exploit the dimension of time, which can lead to significant military advantage. In cases where a swift response to a crisis is required, aircraft enable the rapid deployment of troops and equipment, or can attack a target, in a matter of hours, rather than days. Speed also allows air power to capitalise on the element of surprise and reduces aircraft exposure to hostile fire.²⁴

.....
²⁴ Surprise is a principle of war. See Joint Doctrine Publication (JDP) 0-01, *UK Defence Doctrine*, for more details on the Principles of War.



The F-35 is a multi-mission capable aircraft

3.4. **Reach.** About 70% of the Earth’s surface is water, but all of it is covered by air, and since aircraft are not impeded by natural terrain or physical barriers, they can theoretically access any point on or above the Earth’s surface.²⁵ The reach of air power therefore provides the opportunity to observe and influence operations in the maritime and land environments, regardless of their location.

3.5. **Agility.** Underpinned by the multi-role, multi-mission capabilities of many aircraft, air power is highly agile. It can be shifted quickly and decisively between the strategic, operational and tactical levels of warfare, just as the point of application can be shifted across more than one theatre of operation.²⁶ The scale and scope of activities can be adjusted, in terms of weight of effort or type of operation, even whilst aircraft are airborne.²⁷ Threats can be countered and opportunities exploited, as and when they arise, by flexing air capabilities between roles and missions.

3.6. **Ubiquity.** The combination of height, speed and reach of air power, and its increasing persistence, enabled by air-to-air refuelling and high endurance unmanned aircraft, offer the theoretical potential to be everywhere, hence the attribute of ubiquity. This enables aircraft to pose or counter threats simultaneously and across a

.....
²⁵ The increasing development and proliferation of advanced anti-access and area denial (A2AD) technologies could challenge the reach of air power, unless appropriate counter strategies or tactics continue to be developed.

²⁶ If unconstrained by national boundaries.

²⁷ Aircraft can be re-tasked in the air to perform in another role to meet urgent operational needs at short notice.

far wider area than surface capabilities, offering the ability to deliver overwhelming force whenever and wherever it is required.²⁸

The air power attributes of height, speed and reach enable and enhance the attributes of agility and ubiquity, allowing access to various targets or points of interest across different levels of warfare. Combined, all of these attributes provide air power’s characteristic **flexibility** as an extremely responsive and scalable military tool of national power.

Section 2 – The roles of air power

3.7. There are four fundamental roles of air power: control of the air; intelligence, surveillance and reconnaissance; attack and air mobility. These four roles are shown in Figure 3.1.

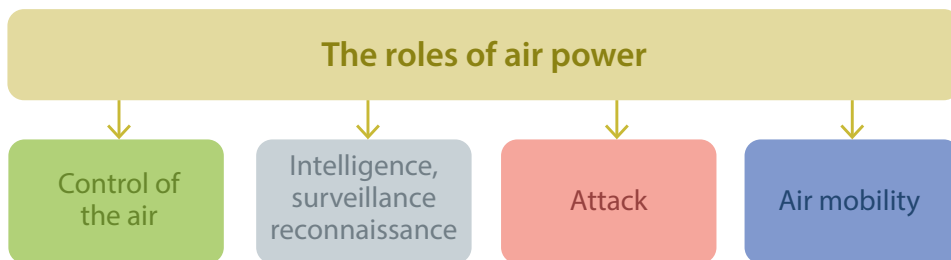


Figure 3.1 – The roles of air power

Control of the air

3.8. Control of the air underpins all air operations, as it secures freedom of action in the air domain, while limiting or denying its use by an adversary. It is this role which protects the UK, Overseas Territories and deployed forces from attack by an adversary. It also assures freedom of manoeuvre across the maritime and land domains, enabling forces to dominate the battlespace and seize the initiative. Control of the air is a relative condition and depends on available resources and the risk that a commander is prepared to accept. Maritime and land operations can be conducted without achieving control of the air in advance, but the associated risks could be significant. There are two degrees of control of the air that are described in Allied Joint Publication (AJP)-3.3(B), *Allied Joint Doctrine for Air and Space Operations*.

²⁸ The ubiquity of air power can be challenged by A2AD threats.



Control of the air is **not a permanent state and constant activity is required in order to achieve it.**



- a. **Air superiority.** That degree of dominance in the air battle of one force over another, which permits the conduct of operations by the former, and its related maritime, land and air forces at a given time and place, without prohibitive interference by the opposing force.
- b. **Air supremacy.** The degree of air superiority where the opposing air force is incapable of effective interference. It is important to note that even air supremacy cannot guarantee that an adversary will not inflict some damage or losses, particularly given the extensive proliferation of small arms weapons and man-portable air defences.

3.9. Control of the air is not a permanent state and constant activity is required in to achieve it. To gain and maintain the required degree of control of the air, counter air operations are conducted to disrupt, degrade, deny or destroy an adversary’s ability to challenge such control. Counter air operations comprise two key missions: **offensive counter air (OCA)** and **defensive counter air (DCA)** missions.

- a. Offensive counter air missions target enemy air capabilities as close to their source as possible. They are generally proactive in nature and seek to dominate an adversary’s airspace, preventing the launch of threats against our forces by affecting them on the ground, along with their supporting systems. Although primarily conducted by manned or unmanned aircraft, they can also be conducted by land artillery, naval surface fire or special forces targeted directly against adversary air capabilities.²⁹
- b. Defensive counter air missions are generally reactive in nature and seek to nullify or reduce the effectiveness of enemy air and missile threats, through active or passive measures. Active measures include methods of detection, interception and engagement, which are usually achieved via a system of layered defence-in-depth using reactive air-to-air fighters; surface-to-air missile (SAM) systems and additional aircraft placed on ground or airborne alert.³⁰ Passive measures include the defence and protection of friendly forces through: early warning; camouflage, concealment or deception; hardening, dispersal or low observable ‘stealth’ capabilities.³¹

3.10. **Challenges to control of the air.** Western air power has dominated recent conflicts, ensuring a high degree of control of the air, helping enable low-risk operations in other domains. This has led to an expectation of a similar degree of control for future air operations. However, we cannot assume a similar domination

29 See Air Publication (AP) 3002, *Air and Space Warfare*, Edition 3, Chapter 6, for more detail on individual offensive counter air missions.

30 See Joint Warfare Publication (JWP) 3-63.1, *Ground Based Air Defence* for more details.

31 See AP 3002, Chapter 6, for more detail on individual defensive counter air missions.

of the air domain for all future operations, due to the threats from increasingly sophisticated anti-access and area denial (A2AD) capabilities, including electronic warfare, cyber and surface-to-air missile systems. Such capabilities are designed to prevent deployment to a theatre of operations, or deny air operations in theatre. The emerging threat from hostile unmanned aircraft also challenges control of lower airspace, threatening land and maritime forces. We must therefore continue to develop counter A2AD and unmanned aircraft system technologies to ensure freedom of action in a contested, degraded and operationally-limited domain.

Operation GRANBY *versus* Operation CORPORATE

Operation GRANBY was the UK's military contribution to the United States (US) – led coalition that freed Kuwait from Iraqi occupation in 1991. The Iraqi Army was the fifth largest in the world and President Saddam Hussein intended to inflict an unacceptable level of casualties on the coalition. However, the coalition exploited their comparative advantage, air power, to avoid fighting on his terms. Control of the air was quickly achieved, enabling coalition air forces to switch the main effort to counter-land operations against Iraqi ground forces. This was so successful that the Iraqi Army's combat capability was vastly reduced by the time the coalition launched the land offensive and helped ensure a decisive victory with only a few coalition casualties.

In comparison, it was difficult to secure control of the air with the limited carrier-borne capabilities available for Operation CORPORATE, the UK's 1982 campaign to retake the Falkland Islands. The continuing Argentinean air threat meant that the carrier group had to remain east of the Islands, after landing the task force at San Carlos. The range to the combat zone also limited the time that fighters could spend on task. With only partial air cover available, some Argentinean aircraft penetrated the defensive screen provided by the Royal Navy's frigates and destroyers, inflicting significant losses on the task force. Sufficient control of the air was attained to ensure that the campaign was successful, but the margins were fine. The Falklands conflict highlights the potential risks if a campaign is mounted without assurance of control of the air.

3

Intelligence, surveillance and reconnaissance

3.11. The use of aircraft changed how the battlespace was viewed, as they provided an alternative perspective to that offered by maritime or land platforms. The intelligence, surveillance and reconnaissance (ISR) role develops situational awareness and enhances understanding, helping shape the conduct of operations. The synchronisation of information collected from aircraft and the subsequent processing, exploitation and dissemination (PED) identifies trends, linkages and threats. It supports decision-making, by enabling the identification of an adversary's

“ The speed offered by manned aircraft makes them among the most responsive of ISR platforms. ”

dependencies, vulnerabilities and strengths. ISR consists of three linked ‘inform’ functions.

- a. **Intelligence.** Aircraft do not directly deliver intelligence but provide timely, accurate and relevant information that is processed and disseminated, and potentially combined with other sources of information to provide intelligence. Intelligence informs political and military decision-making processes and makes a major contribution to the assessment of when and how specific objectives or an end-state might be achieved.
- b. **Surveillance.** Surveillance is the continuing and systematic observation of a wide area of interest. The area of interest can be in any one of the air, surface or sub-surface environments, observed by visual, aural, electronic, photographic or other means. It is not orientated towards a specific target, but designed to provide warning of broad adversarial initiatives and to detect potential threats.
- c. **Reconnaissance.** Reconnaissance complements surveillance, by observing a specific area of interest, to gain specific information about specific activities. Intelligence that is critical to the prosecution of current operations is often derived from reconnaissance operations, so it should be evaluated and transmitted with minimum delay to those elements that need the information.

3.12. The speed offered by manned aircraft makes them among the most responsive of ISR platforms and their reach gives them the ability to fly long distances and cover vast areas, collecting information from a variety of sensors. Radar, acoustic, imaging and signals intelligence sensors have varying but complementary operating characteristics, offering a spread of options. Crews are trained to recognise and respond to changing conditions by modifying missions whilst they are in progress, and share information gained from on-board systems through voice or data links.³² Due to their relatively limited speed, unmanned aircraft are not as responsive, but they can offer significant persistence when compared to manned aircraft. Improved technology on unmanned aircraft also enables the distribution of large volumes of information in real time or near-real time.

3.13. The effectiveness of individual ISR capabilities can be increased by networking them into a system. For example, a surveillance sensor on a given ISR aircraft can observe a wide area before cueing higher resolution sensors with a narrower field of view to conduct reconnaissance on a specific point of interest. Secure network

.....
³² Short-notice modification of missions can be enhanced by near-real time processing, exploitation and dissemination (PED) support.



The RC-135W Rivet Joint provides a significant ISR capability

systems also enable multiple platforms to benefit from the ISR capabilities generated and shared by a single aircraft.³³

3.14. Historically, large ISR aircraft provided the majority of air-enabled ISR but they are no longer limited to those aircraft or sensors that were specifically designed for this role. The increasing sophistication of airborne sensors has resulted in many aircraft being able to conduct ISR, even if it is not their primary mission. Unmanned aircraft, helicopters and fast-jets all provide significant input to the ISR network. However, unlike large, multi-crew ISR aircraft, non-dedicated ISR aircraft do not always have an associated analytical capability, or the means to effectively disseminate information.

3.15. **Challenges to intelligence, surveillance and reconnaissance.** There are significant PED demands associated with collecting large volumes of data by a number of multi-spectral sensors. This presents the challenge of providing decision-makers with fused intelligence that they can act on, rather than proliferating data from a multitude of systems that may swamp decision-makers with un-actionable information. Some ISR sensors can also be negatively impacted by poor weather conditions and the use of camouflage and concealment techniques. However, by using a broad spectrum of sensors on a variety of aircraft, some of these challenges can be overcome.



The Zephyr high altitude pseudo satellite has the ability to remain airborne for 14 days

³³ Link-16 is an example of a secure network system used by many UK aircraft to share information.

3.16. **The impermanence of air power.** Impermanence has historically and justifiably been recognised as a limitation of air power and it is one which particularly affects the ISR role. However, although aircraft are not able to remain airborne indefinitely, the increased loiter time of unmanned aircraft has brought significant benefits as points of interest can be monitored potentially uninterrupted, particularly when a handover is facilitated between multiple platforms.³⁴ Furthermore, the Ministry of Defence (MOD) is expanding ISR capabilities by harnessing emerging technologies to overcome the challenge of impermanence, as demonstrated by the acquisition of high altitude pseudo satellites (HAPS), such as Zephyr.

Attack

3.17. The use of overwhelming force through an attack from the air lies at the heart of the ability of air power to influence the behaviour of actors and the course of events. Air attack can deter adversaries, disrupt their activities, or ultimately defeat them by destroying their resources and capabilities. UK air power is equipped with a broad spectrum of precise weapon technologies, offering the ability to decisively shape the battlespace, in any weather conditions, day or night. The attack role consists of four mission types: strategic attack; counter-land operations; counter-sea operations and information operations. Figure 3.2 illustrates this breakdown.

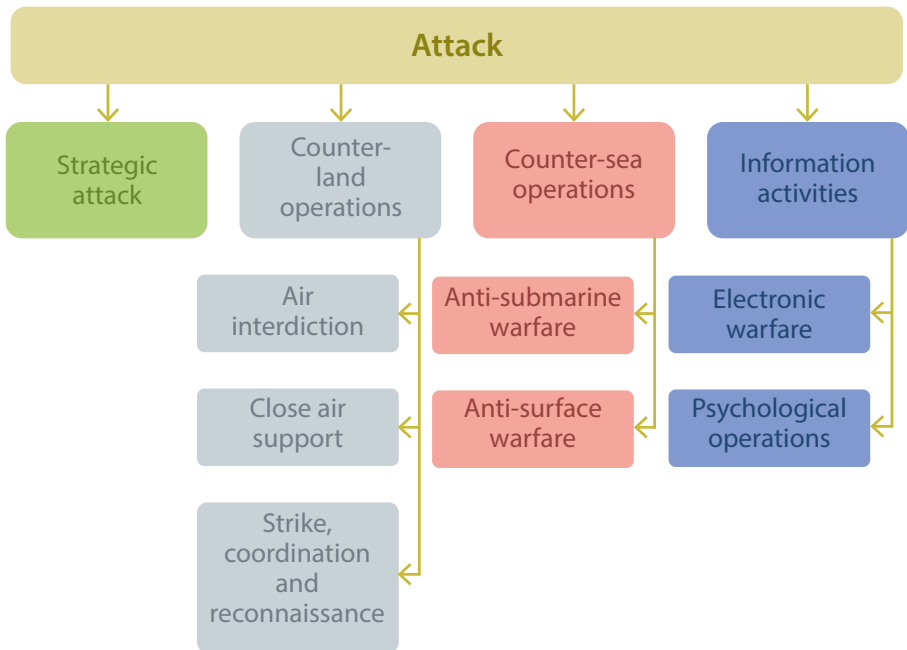


Figure 3.2 – The breakdown of the attack role

34 A 'handover' between manned and unmanned aircraft to maintain constant coverage of a specific area of interest became common practice during recent operations in the Middle East.

a. **Strategic attack.** These operations are aimed at an adversary's fundamental ability to wage war, by attacking their structures or organisations. Targets may include centres of gravity, such as leadership and command elements, critical war production resources or key supporting infrastructure. In this context, 'strategic' describes the effect, not the location or distance to the target, or type of weapon system or delivery platform. It is most effective when a wide array of targets are attacked simultaneously, causing maximum shock effect, placing significant stress on an adversary's processes and limiting their ability to adapt and react.

b. **Counter-land operations.**³⁵ These operations are conducted to defeat an adversary's fielded forces, destroy their supporting infrastructure or generate psychological effects to shatter their cohesion or will to fight. Counter-land operations are also a force multiplier, as they enhance the potency of land forces, allowing them to achieve their objectives while minimising the risk of casualties. They consist of three mission types: air interdiction, close air support and strike coordination and reconnaissance.

(1) **Air interdiction.**³⁶ This action is taken to disrupt, degrade, deny or destroy an adversary's capabilities before they can be used against friendly forces. Air interdiction targets elements such as enemy personnel, lines of communication, command and control nodes, logistics and supporting systems at ranges beyond which an adversary can engage friendly land forces. It can be conducted in support of friendly land force operations but since it is carried out at significant distance from their location, detailed integration is not required.



A RAF Typhoon conducts an air interdiction training sortie

.....
 35 Allied Joint Publication (AJP) 3.3-(B), *Allied Joint Doctrine for Air and Space Operations* refers to counter-land operations as 'air power contribution to counter-land operations'.

36 The British Army, through Joint Helicopter Command, refers to the role of 'aviation attack', which is the use of attack helicopters to conduct a deliberate attack, in a similar vein to air interdiction.

//
Close air support can be **crucial to the success or survival of land forces**, as has been **proven during operations in Iraq and Afghanistan**.
//

(2) **Close air support.**³⁷ Close air support (CAS) is the action taken to disrupt, degrade, deny or destroy enemy activity or capabilities which are in close proximity to land forces. It complements land force ground attack capabilities with significant firepower to coerce adversary forces. Consequently, intensive air-land integration and coordination is critical to accurately identify targets and minimise the risk of fratricide. Close air support can be crucial to the success or survival of land forces, as has been proven during recent operations in Iraq and Afghanistan.

(3) **Strike, coordination and reconnaissance.** Strike, coordination and reconnaissance (SCAR), is a hybrid of the air interdiction, CAS and ISR missions, where combat aircraft detect and subsequently coordinate air attack or reconnaissance of targets. SCAR aircraft perform a deconfliction role for other aircraft in the vicinity of the target area, providing prioritised targeting guidance and updates on adversary activity.

c. **Counter-sea operations.**³⁸ Air power can be used to conduct direct action in the maritime domain, or enable and enhance surface and sub-surface capabilities.³⁹ Counter-sea operations are the employment of air attack in the maritime domain and consist of two mission types: anti-submarine warfare; and anti-surface warfare.⁴⁰

(1) **Anti-submarine warfare.** These operations search for, locate, track and attack submarines and their support assets. Sensors can be used to detect submarines, including radar, electro-optical sensors, magnetic anomaly detection devices, and active or passive acoustic sensors.⁴¹

(2) **Anti-surface warfare.** These operations detect and engage adversary maritime surface forces. The type of support provided by aircraft depends on operational requirements and on their capabilities but can include detection, location, identification, tracking and, ultimately, attack.⁴²

.....
37 Although all three single Services conduct close air support (CAS), the British Army, through Joint Helicopter Command, refer to 'close support fires', of which there are two sub-sets – CAS and close combat attack (CCA). The level of detailed integration planning will determine whether an attack helicopter operates in the CAS or CCA role, CCA being more integrated. See Allied Tactical Publication (ATP)-49, *Use of Helicopters in Land Operations* for more details.

38 AJP 3.3-(B), *Allied Joint Doctrine for Air and Space Operations* refers to counter sea operations as 'air power contribution to counter-maritime operations'.

39 Air-maritime integration will be discussed in more detail in Chapter 4.

40 The Royal Navy refers to attack from aircraft carrier based, fixed-wing aircraft as 'carrier strike'. See Fighting Instructions Book of Reference (digital) 4487 Volume 2.1, *Strike Warfare* and JDP 0-10, *UK Maritime Power* for more detail on maritime-air operations.

41 These functions can be performed by either manned or unmanned aircraft and some of the devices can be delivered into the sea, in order to aid detection.

42 The Royal Navy refers to attack missions conducted by helicopters as 'rotary wing strike'. See Fighting Instructions Book of Reference (digital) 4487 Volume 2.1, *Strike Warfare* for more details.



The Royal Navy Wildcat carries out anti-submarine and anti-surface warfare missions in the attack role, as well as missions in the ISR role

d. **Information activities.** Air attack is primarily associated with the ability to deliver lethal weapons but an adversary can also be influenced by non-kinetic means. Air-delivered information activities use non-lethal effects to influence the behaviour, will and understanding of an adversary, aiming to affect perceptions and shape behaviours and attitudes. Although information activities consist of multiple elements, key areas of focus for air power are: electronic warfare and psychological operations.⁴³

(1) **Electronic warfare.** Electronic warfare aims to assure freedom of action across the electromagnetic spectrum (EMS) whilst denying an adversary such freedoms. It includes electronic protection to assure freedom of action for friendly forces, as well as electronic attack, which can increase the scope of available options, offering a non-kinetic action against adversary capability. Electronic warfare techniques can be debilitating and when compared to kinetic weapons can also be something of an unknown quantity. When considered in the context of the pervasiveness of information via social media and the political risk of collateral damage caused by kinetic weapons, electronic attack may be more politically acceptable.

.....
 43 Information activities include: media operations; psychological operations; deception; electronic warfare; engagement; special capabilities; civil-military cooperation (CIMIC) and operations security (OpSec). See AJP-3.10, *Allied Joint Doctrine for Information Operations* and AP 3002, *Air and Space Warfare* for more details.

(2) **Psychological operations.** Psychological operations seek to create influence through non-lethal means, rather than physically attacking an adversary's combat capabilities. Air operations for psychological effect can include the overt presence of unmanned aircraft overhead, an air-drop of leaflets or using radio broadcasts to support messaging, or even the significant shock effect created by a low altitude, high speed, 'show of force' by a fastjet. Such adaptable and scalable options can be employed to encourage changes in behaviour in accordance with specific objectives.

Psychological operations – Operation SHADER

During Operation SHADER, coalition leaflets were dropped from aircraft with the aim of aiding besieged civilians in Mosul, by explaining how to purify water, cook on a makeshift stove or protect themselves from the intense fighting. The psychological operations element of this activity was that the leaflets bore the symbols of both the Iraqi Government and Armed Forces. Consequently, although primarily a humanitarian operation, the leaflets had the secondary effect of instilling trust and increasing confidence in the government and military forces, whilst further undermining Daesh's perceived legitimacy.

3

3.18. **Targeting.** As well as the ability to reach the intended target, by penetrating enemy air defences or countering complex A2AD strategies, a successful attack depends on the ability to correctly match effects for targeting. Furthermore, the credibility of our attack capability is dependent on the political will to use force, as articulated within a full spectrum targeting and effects process, to make best use of the array of lethal and non-lethal options that air power offers. UK air power is therefore reliant on effective targeting capabilities to conduct effective attack operations to achieve political and strategic objectives.⁴⁴

3.19. **Challenges to attack.** The success of an air attack is largely dependent on the ability of aircraft or weapons to penetrate or counter adversary air defences, and these have become increasingly capable. There are also practical limits to the number of weapons that aircraft can carry, particularly fastjets. However, this challenge has been mitigated by the development of precision guided weapons technology, which has led to the same or even greater effect being created with a fewer number of weapons.⁴⁵ Poor weather can also hinder attack operations but the development of a wide range of weapon guidance options, such as laser, Global Positioning System

44 For more details, see Joint Service Publication (JSP) 900, *UK Joint Targeting Policy*, AJP-3.9, *Allied Joint Doctrine for Joint Targeting* and AP 3002.

45 Unguided weapons fall from an aircraft at the mercy of factors such as wind and are less accurate. By comparison, smart 'guided' weapons, use laser, Global Positioning System (GPS) or radar guidance to precisely attack a target.

(GPS) or radar guidance have mitigated this challenge and provide significant operational and tactical flexibility. Air attacks can therefore be conducted by day or night, in adverse weather conditions, which can provide a distinct advantage if an adversary lacks such capabilities.

Air mobility

3.20. Air mobility provides the ability to deploy, sustain and recover personnel and equipment, often over significant distance. The speed and reach of air power offers the ability to create rapid strategic influence, in support of UK national objectives or in support of a key ally, such as through the insertion of special forces or delivering humanitarian aid due to a natural disaster. At the operational and tactical levels, air mobility supports land operations, enabling manoeuvre when movement on land is particularly difficult due to poor terrain, roads or unacceptable threats to land forces. Air mobility consists of three mission types: airlift; air-to-air refuelling and personnel recovery, these are illustrated in Figure 3.3.

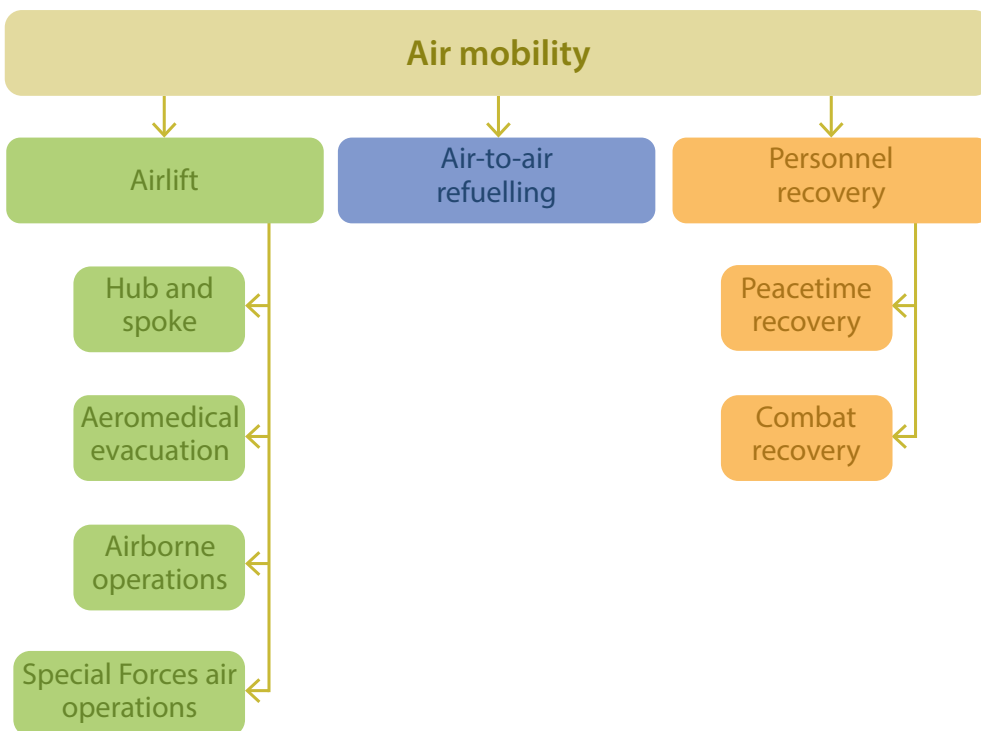


Figure 3.3 – Air mobility

a. **Airlift.**⁴⁶ This is the ability to transport personnel, equipment and materiel through the air. Airlift is subdivided into: hub and spoke operations; airborne operations; aeromedical evacuation and special forces air operations.

(1) **Hub and spoke operations.** Hub and spoke operations consist of inter- and intra-theatre airlift and are the cornerstone of airlift operations, delivering personnel and/or equipment as required. Inter-theatre airlift provides the air bridge that links the UK to airfields in, or near, theatres of operations, known as hubs. It is provided by strategic air transport (Strat AT), supplemented by chartered civilian airlift, and augmented by tactical air transport (Tac AT). The hub is the focal point for subsequent intra-theatre airlift to spoke airfields located throughout the theatre of operations. Intra-theatre airlift is normally fulfilled by fixed-wing Tac AT or support helicopters, which are capable of operating under a wide range of tactical conditions, including small, remote field operations.

(2) **Airborne operations.** Airborne operations use specialist aircraft to transport land forces and their equipment directly to, or close to, their objective and subsequently sustain, or extract them, when required. This can be done by either air-land or air-drop operations. Air-land delivery is when an aircraft lands directly at its objective to unload, whereas air-drop is delivery from an aircraft in flight, using parachutes.⁴⁷



British Army paratroopers conducting an airborne operation exercise in Spain

⁴⁷ Airborne operations can also include support of littoral manoeuvre operations.

(3) **Aeromedical evacuation.** This is a specialist form of airlift that transports injured or seriously ill personnel under medical supervision. Forward aeromedical evacuation is moving injured personnel from the battlefield to appropriate medical treatment facilities. Tactical aeromedical evacuation is moving patients between medical facilities in, or close to, theatre. Strategic aeromedical evacuation operations involve repatriating ill or wounded Service personnel to the UK from in-theatre medical facilities, primarily in specially equipped and manned aircraft.⁴⁸

(4) **Special forces air operations.** These are air operations conducted by specialist aircraft and personnel which enable the insertion, sustainment and extraction of UK Special Forces. Special forces are specially organised, trained and equipped personnel who support strategic or operational objectives by unconventional military means, often in hostile, denied or politically sensitive areas. Although all four air power roles could be used to support special forces operations, having the ability to rapidly move high-value personnel in support of high priority political objectives is a critical capability.

b. **Air-to-air refuelling.** Air-to-air refuelling significantly increases the reach, endurance and flexibility of air power and is therefore a crucial capability. It enhances strategic and operational mobility, by helping to mitigate access issues caused by a lack of basing options, overflight limitations, or A2AD threats that may otherwise constrain air operations. It also improves the persistence, availability and responsiveness of tactical air operations by maximising the duration of combat aircraft.⁴⁹ Air-to-air refuelling can allow multi-role aircraft to be reassigned to other objectives once they have achieved their primary mission, thus enabling economy of force.



An interior image of an RAF Voyager tanker refuelling a Typhoon during Operation SHADER

⁴⁸ For more detail on aeromedical evacuation operations, see AJP-4.10(B) *Allied Joint Medical Doctrine for Medical Support* and AP 7002, *Air and Space Warfare*.

⁴⁹ By increasing the flight time of combat aircraft, they can extend their combat air patrols in support of a control of the air mission, remain airborne to attack more targets in an air interdiction mission, provide longer support to land forces in a close air support mission, or gather time-critical reconnaissance information in the ISR role.

c. **Personnel recovery.** Personnel recovery operations use air mobility capabilities to rescue captured, isolated or missing personnel during combat or peacetime operations. Personnel recovery is subdivided into peacetime recovery or combat recovery operations.⁵⁰ **Peacetime recovery operations** are undertaken to recover personnel where no threat is posed by hostile interference, such as mountain search and rescue operations or assistance to the civil authorities. **Combat recovery operations** extract isolated personnel from a situation where hostile interference is expected. It is therefore amongst the most time-sensitive of air operations.

3.21. **Challenges to air mobility.** There are practical limits to the payload that aircraft can carry but this limitation needs to be offset against the advantages offered by speed and reach. Maritime platforms can move significantly more personnel and equipment in support of military operations but at significantly slower speeds. Also, movement on the ground is relatively time consuming and can be hindered by terrain or contested by a threat. Air mobility therefore balances the challenge of a limited payload with the military advantages offered by speed of action. Air mobility aircraft can also be more vulnerable to air and ground launched threats, due to their size, relatively slow speed and limited manoeuvrability. However, this can be mitigated by using ISR aircraft to understand the threats posed in a given theatre of operations before the air mobility aircraft are deployed. Continually advancing platform protection capabilities will also mitigate the threat posed to aircraft.

Summary of the roles of air power

3.22. Although the four roles of air power are treated as being distinct, as depicted in Figure 3.4, there is also overlap. Modern, multi-role aircraft afford a significant degree of simultaneity, whereby a single aircraft can perform more than one role, even during the same mission if necessary. For example, an RAF Typhoon can be re-assigned whilst airborne to conduct elements of control or the air, ISR, or attack missions. As technology advances and multi-role aircraft continue to be developed, there is potential for the overlap between roles to increase further. This is a key strength of air power, as simultaneity bolsters its agility, flexibility and adaptability.

.....
⁵⁰ For more detail on personnel recovery operations, see JSP 911, *Survival, Evasion, Resistance and Extraction* and Air Publication 3002, *Air and Space Warfare*.

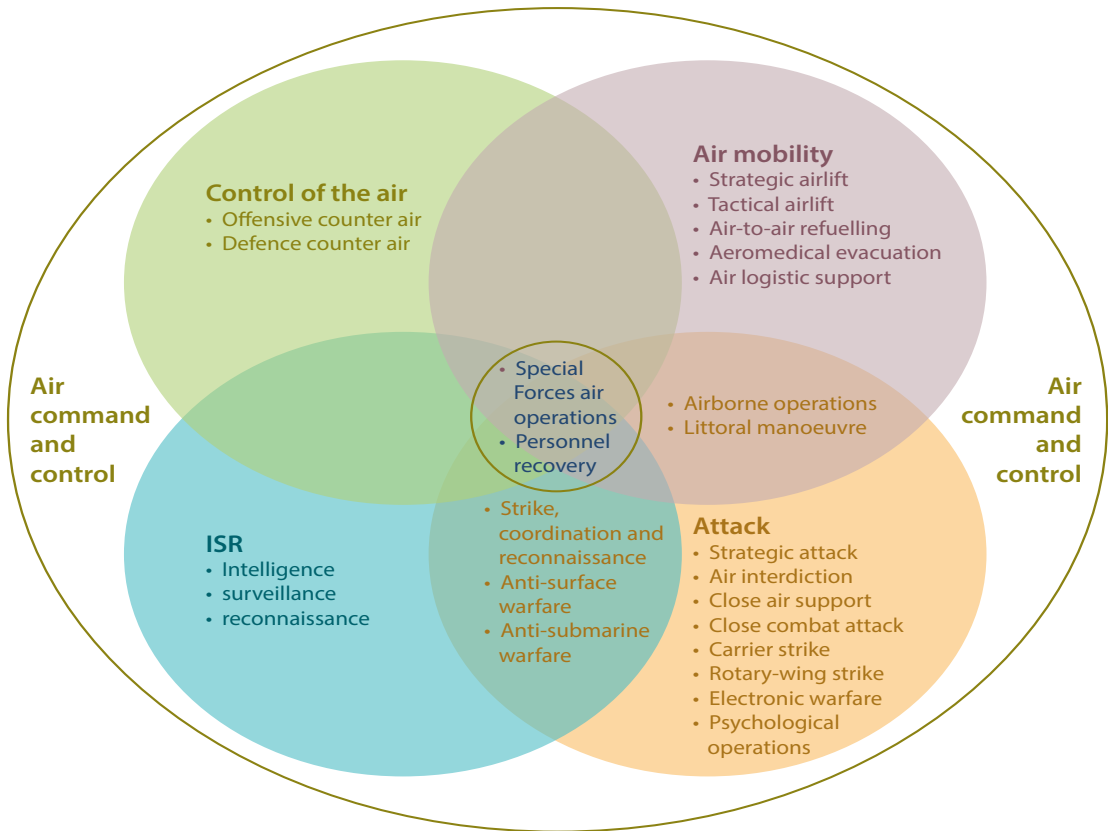


Figure 3.4 – Summary of the roles of air power, and their associated missions

Air command and control

3.23. Figure 3.4 also depicts the fact that command and control envelopes all four air power roles. Aircraft are highly sought after because they are able to pursue strategic, operational and tactical objectives simultaneously. However, they can be limited in numbers or availability, so there is significant potential for fragmentation of the air effort. A component request for tactical air support could compete with the allocation of the same air resource for operational or strategic objectives.

3.24. Competing demands must be prioritised and apportioned accordingly, hence the requirement for centralised control, which ensures that aircraft are used as efficiently as possible to achieve military objectives. It prevents them from being inappropriately tasked by uncoordinated users against impractical objectives, or being divided into small packages of air power that would inhibit flexibility and hinder any requirement for a rapid concentration of force. Depending on the strategic, operational and tactical context, there are options to adapt between

three levels of command and control to suit a specific operation or task. These are illustrated in Figure 3.5.

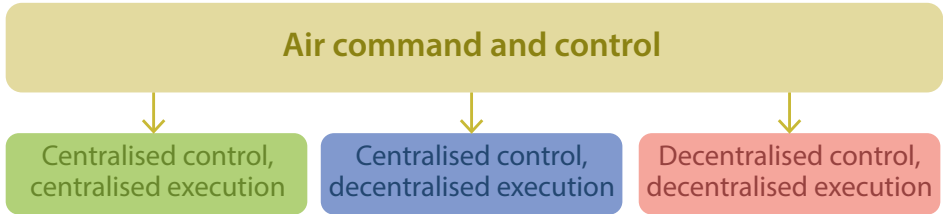


Figure 3.5 – Air command and control structure

- a. **Centralised control, centralised execution.** Centralised execution authority may be necessary in certain operational circumstances where the stakes are particularly high or where the highest-value assets are being employed. It might also be appropriate when there is a requirement to closely manage air activities that might have strategic effects, even though this may adversely affect tactical efficiency. A potential disadvantage of centralised execution authority is that it can result in a rigid approach which lacks tactical flexibility and is not responsive enough to local conditions. As a result, it may only be suited to specific operations for short periods of time.
- b. **Centralised control, decentralised execution.** Air activities can take place simultaneously across single or multiple theatres of operation. However, no single entity is likely to have the level of awareness required to manage all concurrent activities, so the execution can be decentralised. Modern, networked communications have increasingly enabled execution authority to be decentralised, allowing on-scene commanders to make rapid decisions in complex, dynamic situations. This include the delegation of weapons-release authority to aircrew, shortening the decision cycle and increasing speed of action. It can also be the only feasible option for complex air campaigns, where beyond line-of-sight communications may be degraded or denied.
- c. **Decentralised control, decentralised execution.** The decentralised control and execution of air power may be allocated to subordinate commanders for specific periods of time to improve responsiveness. Nominated air units could integrate as specific task-focussed and organised joint teams for certain operations.

Centralised control, centralised execution – Operation ENDURING FREEDOM

Centralised control, centralised execution is necessary in certain circumstances, but it can also increase risk, as it reduces operational tempo. In October 2001, the operators of a United States (US) remotely-piloted aircraft pinpointed the location of the supreme leader of the Taliban, Mullah Muhammad Omar, as he fled Kabul amongst a convoy of cars. As neither the remotely-piloted aircraft controllers, nor the US Navy Fifth Fleet commander in Bahrain, could authorise a strike, approval had to be sought from US Central Command in Tampa, Florida. The ensuing delay for strike approval allowed Mullah Omar to escape.

Section 3 – Fighting power

3.25. Fighting power is at the core of every military Service, as it defines the ability to conduct successful operations. It is not simply a calculation of the number of people and equipment, it is also the ability to maximise the potential of such equipment and the ability to motivate people to fight. While these aspects are common across all domains, the different attributes and roles of air power offer a unique contribution to military power and therefore a unique perspective on fighting power.⁵¹

3.26. In its application, fighting power should take account of the context and character of the situation, considering: the environment; the opponent; allies, partners and other agencies; and culture and history. It is made up of an essential mix of three interrelated components: conceptual; physical; and moral.

The conceptual component

3.27. The conceptual component is the intellectual basis and theoretical justification for providing and using armed forces. The elements of the conceptual component provide a framework of thinking for military personnel to develop an understanding of their profession. It reflects accumulated experience but also considers analysis of the future and innovative ideas. This is especially critical when considered against the context of the contemporary operating environment.⁵² The increasing development and proliferation of advanced air and counter-air capabilities means that a qualitative or quantitative advantage cannot be assured in the physical component. It is

.....
51 For more detail, see JDP 0-01, *UK Defence Doctrine*.

52 As described in Chapter 2.

therefore fundamentally important that the conceptual component is used to gain and maintain advantage, through the development of war-winning capabilities.

The physical component

3.28. The physical component is the means with which to fight, providing balanced and agile forces at the appropriate level of readiness and sustainment. The successful employment of air power relies heavily on credible war-fighting equipment but in order to maximise its operational effectiveness, perceptive, dynamic and motivated people are required to operate the equipment. In the contemporary operating environment, air power needs to be agile and adaptable, so the physical component must provide capabilities that can fulfil a wide range of tasks. There is also a balance to be struck between investing in the right type, quality and quantity of equipment; the decision on where the balance lies ultimately depends on the threat faced and risk appetite.

The moral component

3.29. The moral component is the ability to get people to fight, individually and collectively. It is the shared values and standards, and the moral cohesion that binds individuals together in a team, to effectively deliver air power. It motivates ordinary people to overcome fear or adversity and achieve military objectives in pursuit of a common goal. It is fundamental to operational effectiveness that the components of ethos are understood, upheld and passed on, since once they are lost they will be difficult to recover. The willingness of personnel to fight and to support the fight, demands strong leadership and unwavering commitment, built on a shared set of core values.

3.30. The conceptual, physical and moral components are interlinked since fundamentally, it does not matter how good the aircraft, weapons and systems are if the people manning them lack motivation, training or adequate leadership. The conceptual component sits above the moral and physical components, not necessarily because it is more important, but because it defines the direction and shape of the others. This structure is illustrated in Figure 3.6.

3

“
The moral component is the shared values and standards, and the moral cohesion that binds individuals together in a team, to effectively deliver air power.
”

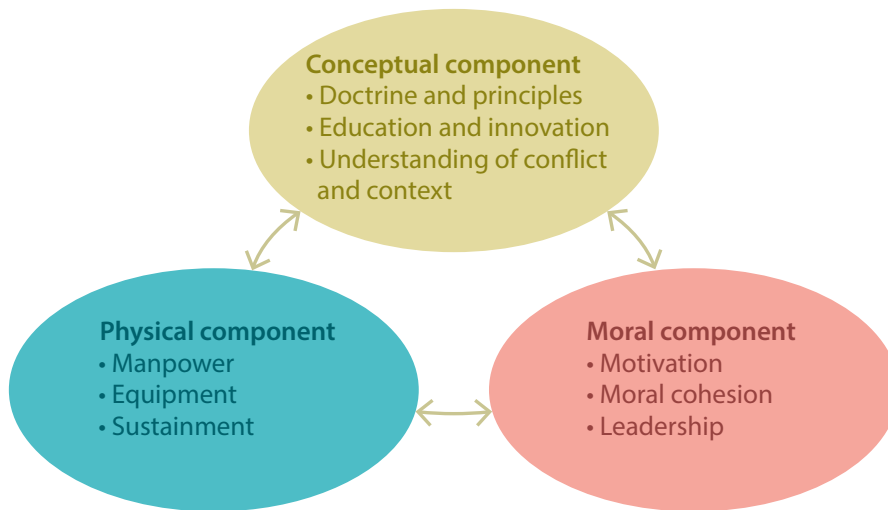


Figure 3.6 – Fighting power is an essential mix of three interrelated components

Key points

- The key attributes of air power are height, speed, reach, agility and ubiquity.
- Combined, all of these attributes provide air power’s characteristic flexibility as an extremely responsive and scalable military tool of national power.
- The four core roles of air power are: control of the air; intelligence, surveillance and reconnaissance; attack; and air mobility.
- We must continue to develop technologies to ensure freedom of action in an increasingly contested, degraded and operationally-limited environment.
- Modern, multi-role aircraft afford a significant degree of simultaneity, whereby a single aircraft can perform more than one role during the same mission.
- Command and control envelopes all four air power roles, as it is essential for the effective delivery of air power.
- Fighting power is at the core of every military Service, and is made up of an essential mix of three interrelated components: conceptual; physical and moral.



The employment of air power

Chapter 4 considers the application of UK air power in the context of a joint and full spectrum approach and highlights how it integrates with other elements of military power. It provides an overview of key air power enablers and highlights air power's contribution to Defence Tasks in support of national objectives.

Section 1 – Joint action, joint operations and the full spectrum approach	49
Section 2 – Cross-domain integration	51
Section 3 – Enabling air power	57
Section 4 – Employing air power in support of Defence Tasks	62

//
Air forces offer the **possibility of striking** at the enemy's **economic and moral centres** without having first to achieve the **destruction** of the enemy's main **forces on the battlefield**. Air power might attain a **direct end by indirect means** by hopping **over** opposition, rather than **overthrowing** it.

//

B. H. Liddell-Hart

Chapter 4 – The employment of air power

Section 1 – Joint action, joint operations and the full spectrum approach

4.1. Air power works most effectively when integrated through a joint approach, with other components of military power, benefiting from **complementary capabilities and exploiting synergies between the maritime, land, air, space and cyber domains**. This can be further enhanced, as military forces are often integrated and synchronised with other government departments, potentially alongside the use of other instruments of national power,⁵³ behind a common national goal. This is referred to as the full spectrum approach, the military component of which is known as joint action.

Joint action

4.2. Joint action is the orchestration of national military capabilities and activities to achieve influence in pursuit of national objectives. It is the combination of offensive and defensive fires, information activities, outreach and manoeuvre, used to affect an actor's will, capability or understanding. Air power contributes to joint action through the exploitation of its attributes and roles. Using the freedom of manoeuvre provided by control of the air, air power can use the attack or air mobility roles to outreach and conduct kinetic and information activities, creating both lethal and non-lethal air effects. It can affect an actor's will, understanding or capabilities, in ways informed by intelligence, surveillance and reconnaissance.

Joint operations

4.3. A joint operation is one where two or more Services operate as a single military force, under a single command structure, to accomplish a specific mission. If deployed with maritime or land forces, air power offers policy-makers with a broad range of military options to achieve specific national objectives. Air power enhances

.....
53 The instruments of national power are diplomatic, military and economic, underpinned by information.

the scale of options for the joint force; through its flexibility and the speed with which it can reach the battlespace, it provides vital projection and sustainment, offering significant military advantage.

4.4. Historic evidence and experience suggests that independent air operations, while significantly contributing to the conduct of a particular conflict, do not have the same potency as joint operations. Aircraft are incapable of occupying land, so land forces will be required, unless a campaign is being fought in which the seizure of enemy held territory is not necessary. As a result, UK air power operates within the context of a joint approach.

4.5. Although the effects of joint action are primarily targeted at an adversary, it has an impact on a wide range of other actors that also need to be influenced. This can include civilian partners, such as non governmental organisations, the UK population, allies and regional audiences. Such engagement and influence helps preserve freedom of action for military operations. Therefore, although joint action implies the use of military capabilities, it may involve coordination or integration with the activities of other government departments and other levers of national power in a full spectrum approach.⁵⁴

Full spectrum approach

4



A Department for International Development representative supervising aid supplies on an RAF C-17

4.6. Effective crisis management requires active cross-government and multi-agency cooperation to develop, employ and sustain a comprehensive and successful response. The full spectrum approach to national power is an approach which deals with a wide variety of challenges by creating and managing strategies to address complex problems.⁵⁵ It employs diplomatic, economic and military instruments of national power, all underpinned by information, to achieve desired political and strategic objectives. The coordination and synchronisation of these capabilities reduces duplication of effort, creates synergies and leads to more effective

⁵⁴ The full spectrum approach develops the integrated approach (described in Joint Doctrine Publication (JDP) 0-01, *UK Defence Doctrine*) by widening it to include all parts of Government.

⁵⁵ See the *Full Spectrum Approach Primer* for more details.

use of resources. UK air power is a key component of the full spectrum approach, as part of the broader Defence input. The relationship between joint action and the full spectrum approach is depicted in Figure 4.1. Joint action coordinates and synchronises:

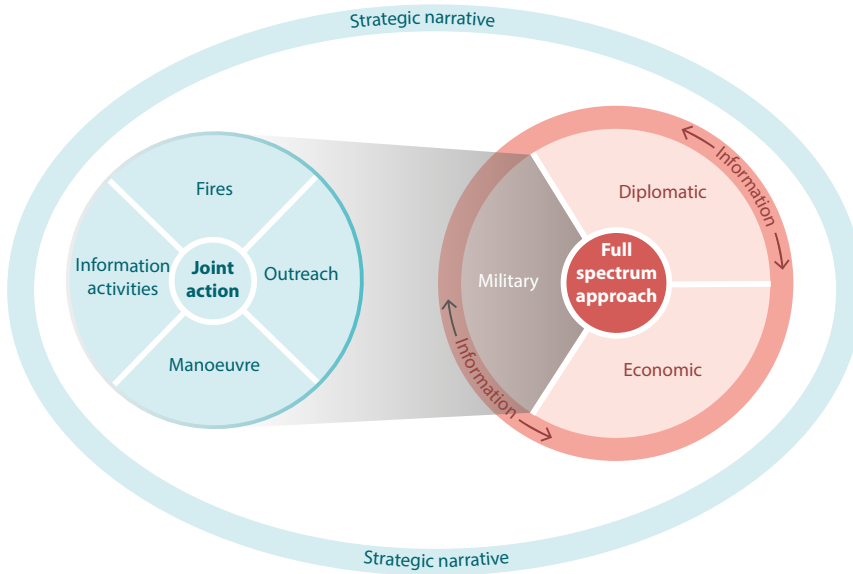


Figure 4.1 – The relationship between joint action and the full spectrum approach

Section 2 – Cross-domain integration

4.7. Joint operations have the potential to be extremely effective because the various capabilities across the single Services complement the strengths and compensate the limitations in each, creating powerful synergies. However, to maximise their effectiveness, they need to be efficiently integrated. The UK focused heavily on air-land integration during recent operations but this may not be sufficient for complex operations along, and across, more than one domain. This is particularly relevant in the complex contemporary operating environment, where operations are likely to require effective integration between the maritime, land, air, space and cyber domains, all underpinned by information.

4.8. Effective cross-domain integration depends on mutual trust and understanding, built on well-established bilateral cooperation between single Services. This leads the way to genuine, cross-domain integration, where a joint approach becomes intuitive. History has shown that bilateral cooperation can be extremely effective

but can also diminish once hostilities end, so efforts must be made to maintain bilateral cooperation through frequent liaison, training and exercises. Furthermore, integration training should consist of wider opportunities than just bilateral activities, including maritime, land, air, space and cyber capabilities to enhance the employment of cross-domain integration, thereby increasing agility across Defence.⁵⁶

Air-land integration

4.9. Air-land integration (ALI) maximises the combat power created by coordinating and synchronising complementary capabilities from the air and land domains. It encompasses all the processes which plan, coordinate, control and de-conflict the activities of the air and land components within a given battlespace.⁵⁷ Air power takes advantage of the strengths of land forces, such as awareness of the land battlespace, whilst compensating for their limitations, such as providing additional firepower to help preserve freedom of action. Effective ALI requires an understanding of the land domain within which such operations are planned.⁵⁸



Joint terminal air controllers exercise air-land integration with an RAF Typhoon

56 The Air Battlespace Training Centre at Royal Air Force (RAF) Waddington enhances air integration training opportunities in a synthetic environment.

57 See Air Publication (AP) 3002, *Air and Space Warfare* for guidance on air-land planning considerations.

58 See JDP 0-20, *UK Land Power* for more detail on UK land power attributes and aspects.

4.10. Whilst control of the air affords freedom of manoeuvre for land forces, effective ALI is necessary to assure timely air support in the intelligence, surveillance and reconnaissance (ISR), attack and air mobility roles. Aircraft in these roles can be allocated to hold varying degrees of readiness in support of land forces, either on the ground, or in the air for urgent on-call tasking. The use of attack in support of land forces, through close air support (CAS) or close combat attack (CCA), requires a high degree of mutual trust and understanding, particularly in dynamic combat situations where there is no clear delineation between enemy and friendly land forces. Operations in Iraq and Afghanistan reinforced the need for suitably qualified air liaison staff at every level and, more fundamentally, suitably qualified joint terminal air controllers (JTACs) to act as an interface between the land force elements and aircraft operators.

Air-maritime integration

4.11. Air-maritime integration (AMI) is the understanding and combination of air and maritime procedures, capabilities and limitations to increase operational effectiveness. It enhances the combat potential of each. The air and maritime domains have certain similarities, such as scale and strategic scope; control of the sea, like control of the air, is an essential prerequisite for freedom of manoeuvre. AMI is required for many operations, particularly where anti-access and area denial (A2AD) threats are faced, that cannot be countered in a single operating domain.

4.12. Close coordination between ISR and combat air capabilities with complementary maritime capabilities can lead to significant synergies.⁵⁹ Maritime air defence capabilities contribute to counter-air or air policing duties through the integration of their anti-air warfare capabilities with land-based aircraft, which helps to establish and maintain control of the air.⁶⁰ However, the effectiveness of such integration depends on the interoperability of individual aircraft and the overall combat system. Consequently, the ability to network information across components and between platforms from separate domains is critical to success.⁶¹

Air-space integration

4.13. Space services provide vital enabling capabilities for all of the operating domains and so air-space integration is critical to the successful employment of air power. The effectiveness and potency of aircraft operations is closely linked to the

59 See Allied Tactical Publication (ATP)-3.3.3.1, *Air Maritime Coordination Procedures* for more details.

60 Such as between the Royal Navy's Type 45 Destroyer, through use of its air defence radar, in support of RAF Typhoon Quick Reaction Alert (QRA) operations.

61 Refer to Chapter 4, Section 3 for more detail on aircraft carrier based air operations.

“
Close coordination
between ISR
and combat
air capabilities
with
complementary
maritime
capabilities can
lead to significant
synergies.”

effectiveness of enabling space capabilities, such as positioning, navigation and timing for aircraft and weapons, or voice and data communications.⁶²

4.14. Effective air-space integration at the operational planning level can also provide opportunities to make use of complementary capabilities. For example, both the air and space domains offer significant ISR capabilities, which, if coordinated during an operation, can complement one another by ensuring there are no gaps in coverage.

Air-cyber integration

4.15. Air-cyber integration is the use of air and cyber capabilities to create desired joint war fighting effects in the physical or virtual battlespace. Air-cyber integration can involve cyber operations in support of air operations, or air operations in support of cyber operations. Cyber operations in support of air operations are divided into defensive and offensive air-cyber operations.

a. Defensive air-cyber operations protect the systems that are relied upon to support the employment of air power.⁶³ The ongoing development of offensive cyber capabilities offers adversaries the potential of targeting such systems, which could have a significant effect on air power employment. Understanding the threat to and vulnerability of these systems will allow an evaluation of the risks associated with a given contested cyber domain. Identifying and understanding such capabilities provides the opportunity to develop means of protection through defensive cyber operations.⁶⁴

b. Offensive air-cyber operations actively target an adversary's cyber capabilities to enable air operations in a contested domain. A computer network could be attacked to degrade an integrated air defence system, enabling otherwise vulnerable aircraft to penetrate hostile airspace. Integrating such cyber effects can therefore help to disrupt and overcome A2AD threats, providing the freedom to attack targets in enemy territory. However, offensive cyber capabilities may need tailoring against specific networks, which might not match the timescales associated with an air power response. The potential use of a cyber weapon to create effect in support of air power therefore needs to be considered early in the planning phase.

62 A comprehensive overview of the space domain is provided in Part 2 – UK space power.

63 Including command and control, logistics, mission planning, air traffic control, intelligence sharing and communications.

64 Cyber Joint User in Joint Forces Command conduct cyber vulnerability assessments of UK military aircraft and systems.

“
Air-cyber integration may involve cyber operations in support of air operations, or air operations in support of cyber operations.
”

4.16. Air operations in support of cyber operations can include kinetic attacks on selected computer nodes to deny an adversary a critical capability or force them to use networks that can be attacked or exploited using cyber capabilities. Such activities must be coordinated through a full spectrum targeting process, to ensure unintended consequences are avoided or managed. For example, a tactical operation by attack aircraft to destroy a bridge as part of an operational level, air interdiction campaign may inadvertently undermine a higher-value, strategic cyber operation if the bridge is carrying fibre optics which support networks that are being exploited.

Air-cyber integration – Operation ORCHARD

On 6 September 2007, Israeli Air Force F-15 and F-16 aircraft conducted an attack on a suspected Syrian nuclear reactor site at Dayr ez-Zor. Syria's Integrated Air Defence System, although consisting largely of early-generation Russian surface-to-air missile systems, also included modern systems, yet all were nullified in advance of the attack. They were disabled by a pre-emptive cyber attack, which enabled the safe ingress of the Israeli combat aircraft and a successful attack on the facility, with no loss of aircraft.

Integrating air command and control

4.17. The UK Joint Force Air Component (UK JFAC) provides the UK with a scalable and deployable command and control capability for UK air operations. Permanently based at RAF High Wycombe, the UK JFAC is structured and equipped to provide a fully capable air component command (ACC) for both national and multinational operations; operating either from a bespoke Air command and control facility at RAF High Wycombe or deployed to meet the demands of a crisis.⁶⁵ The UK JFAC routinely uses centralised planning and decentralised execution to maximise the air contribution to the delivery of joint action. For multinational or North Atlantic Treaty Organization (NATO)-led operations, the UK JFAC is capable of integrating with other Air command and control elements such as NATO Air Command (AIRCOM) or the United States (US) 603rd Air Operations Centre, in Ramstein, Germany, or the French JFAC in Lyon.



A combined air operations centre

⁶⁵ Demonstrating the need for robust communications, including secure satellite communications.

4.18. Large, complex, multinational air operations require a comprehensive command and control capability which is often provided by a fixed combined air operations centre (CAOC). These facilities are usually found in established theatres of operation and provide coordination and synchronisation between all military forces, as well as national and international agencies. Although unified under a national contingent commander, UK air elements are likely to operate under the command of a combined forces air component commander (CFACC), who may be of another nationality. The vast majority of recent UK major air operations have been coordinated by a CAOC, led by a US CFACC.

Integrating air planning

4.19. Joint air planning is usually conducted in parallel with joint operational-level planning.⁶⁶ Qualified and experienced joint air planners should engage early in the development of the operational plan to ensure that it is coherent and workable and that joint air options are fully considered and integrated from the start.⁶⁷ A sound understanding of the wide variety of aircraft and their associated capabilities, as well as an understanding of the capabilities or operations which air power is supporting, is critical to the success of the planning phase.



A RAF Reaper conducting operations overseas

4.20. Unmanned aircraft generate unique planning considerations. Most fly at slower speeds than their manned counterparts, so take significantly longer to travel to an area of interest. Careful consideration therefore needs to be given to the proximity of their basing compared to likely areas of operation. Whilst it can be difficult to shoot down unmanned or remotely piloted aircraft, few have the ability to counter ground or air threats, planners to avoid known sites of hostile threat capabilities. Unmanned aircraft are also significantly more susceptible to poor weather than manned aircraft, due to a greater vulnerability to factors such as icing (caused by cloud), high crosswinds or lightning strikes.⁶⁸

66 See Allied Joint Publication (AJP)-5, *Allied Joint Doctrine for Operational-level Planning* for more details.

67 See AP 3002, *Air and Space Warfare*, Chapter 4.

68 See JDP 0-30.2, *Unmanned Aircraft Systems* for more details.

4.21. Air operations in complex and congested air environments that require coordination with military and civilian airspace authorities can be exceptionally challenging to facilitate and coordinate. The use of unmanned or remotely piloted aircraft in any operation is likely to complicate this issue further, due to the associated challenges with regard to air and battle-space management.

Section 3 – Enabling air power

4.22. The ability to deliver each of the four roles of air power is dependent on critical enablers: **base**; **sustain**; **connect**; and **protect**. Various basing options enable the delivery of rapid effect across the globe; air logistics enable the sustainment of operations; command, control, computing and communication capabilities enable connectivity; and force protection capabilities enable the protection of forces at home and overseas.

Base

4.23. Air power can operate from a range of basing options, providing maximum agility for operations. Basing options include the UK mainland, Overseas Territories, allied and partner bases, sea basing and forward land basing. Each has different access constraints, in terms of staging, overflight, force protection and sustainment and each can provide different political options when projecting power globally.

- a. **UK mainland.** UK basing enables air power to protect the UK mainland and respond to crises almost immediately, without the need for deployed logistic or host nation support. However, to project air power outside the UK, permission may be required to overfly sovereign territories. Even with air-to-air refuelling, the effective operational reach of current air capabilities is limited to Middle Eastern and North African regions and to project air power to any of these regions, prior overflight permission from European allies will be required.
- b. **Overseas Territories.** UK Overseas Territories enable air power to extend its reach to regions of strategic interest, without the requirement for host-nation support. For example, the UK base in Cyprus plays a pivotal role in the ability to project power in support of national objectives. However, Overseas Territories can be particularly reliant on force protection and on logistic support, to sustain operations. Access to Overseas Territories can also be reliant on overflight permissions from other nations.

“
Air power can operate from a range of basing options, providing maximum agility for operations.
”



A Typhoon operating from RAF Akrotiri, a UK Sovereign Base in Cyprus

4

c. **Allies and partners.** Maintaining good relations with allies and partners enables the potential to operate from their sovereign territories in support of UK national or combined coalition objectives. Using such bases can significantly expand global reach but is reliant on maintaining good relations with the host nation. History has shown that allied bases can provide a politically and operationally sustainable means of enduring air operations.

d. **Sea basing.** The sea basing of aircraft enables global reach and the ability to act unilaterally, with reduced dependency on staging or overflight permissions. Ships can be equipped with integrated command and control facilities, capable of directing limited air operations. Sea based combat aircraft can integrate with land based air-to-air refuelling, ISR and maritime patrol aircraft to maximise their effect. Ships are also able to loiter in areas of tension, drawing on the maritime attribute of poise, to deter adversaries, react to events or reassure our allies.⁶⁹

(1) Carrier Enabled Power Projection (CEPP) is the UK term given to describe the capability underpinned by the Queen Elizabeth Class aircraft carriers. It is designed to be an integrated and sustainable joint capability, interoperable with NATO allies and other coalition partners. It draws together the coordinated operation of the aircraft carriers, combat and support aircraft, and enabling capabilities to conduct the four roles of air power. Maritime capabilities can therefore provide complementary

69 See JDP 0-10, *UK Maritime Power* for more detail on maritime power attributes.

ways of projecting air power, either integrated with land-based air forces or independently when deployed at distance from a land base. Royal Navy Fleet Air Arm, RAF and British Army force elements can all operate from the maritime domain as part of a Maritime Task Group.⁷⁰



The Queen Elizabeth Class aircraft carriers will enable the global projection of UK air power

(2) Land and sea basing options are complementary; no single option assures air power's ability to achieve global reach. Combined, they help overcome A2AD threats, which may deny access in their respective domains. Maintaining the ability to operate across a spectrum of basing options, and move seamlessly between them, provides operational flexibility in the contemporary operating environment, where A2AD is a significant factor. We can therefore assess the various basing options and choose where is best to operate from, depending on the scenario and the overarching context.

e. **Forward land-basing.** If access can be gained to an adversary's territory and a basing option secured, it can enhance speed of response, persistence and concentration of support for land forces. Forward land basing can also be essential for force extraction. However, it is dependent on the available infrastructure to support the aircraft type, force protection and the ability to maintain control of the air in the vicinity of the base. It may also require a full suite of deployable enablers, to generate and sustain the deployed force.

Sustain

4.24. Sustainability enables air power force elements to deploy to an area of operations, remaining fully mission capable for a variety of roles. It provides the flexibility to remain on task and operationally capable for as long as necessary. Sustainability is defined as: **the ability of a force to maintain the necessary level of combat power for the duration required to achieve its objectives.**⁷¹ Sustainability is:

- one of the ten principles of war;

⁷⁰ In the attack role, aircraft carriers will support F-35B Lightning, Apache and Wildcat aircraft and in the ISR role, the multi-role Merlin Mark 2 helicopter. For littoral manoeuvre, special forces or expeditionary roles, a mixed air group may be used, comprising Chinook, Merlin air mobility helicopters and Wildcat and Apache attack helicopters.

⁷¹ NATO*Term*.

- the responsibility of commanders at every level of command;
- an integral part of the planning, preparing and executing of, and withdrawal and recovery from, every operation; and
- to be fully exercised in peacetime to be effective in war.

4.25. Air logistics is the ability to plan and execute the movement, maintenance and sustainment of air power. Providing a variety of logistic functions is a complex, dynamic and wide-ranging series of disciplines which can often dictate the operational tempo. It is part of the standard Defence Support Network, but has a particular dependency on reachback for the repair and replacement of high value, complex aircraft. This generates a need for an efficient supply chain and sufficient stocks for contingency operations, which links into UK industry.

4.26. Air logistics operations are conducted in line with the nine logistics principles which were adopted from NATO. The nine principles are: authority; primacy of operational requirements; coordination and cooperation; assured provision; sufficiency; efficiency; simplicity; flexibility; and visibility.⁷²

Connect

4.27. Air command, control, communications, computers and intelligence (C4I) is a key enabler for air power, due to the reliance on robust lines of communication between a multitude of home locations and overseas operational theatres. Information exchange enabled through datalinks at the tactical and operational levels enables force survivability, shared situational awareness and ultimately, information superiority; all critical to mission success in any complex, contested battlespace.

4.28. The successful sharing of information and data gathered on operations requires a high degree of reliable connectivity and interoperability between participating units and platforms. Some aircraft systems also require connectivity to the internet in order to operate effectively. The overall C4I solution must enable seamless integration of information whilst safeguarding sensitive data and securing the networks from attack, compromise or failure.

.....
72 See JDP 4-00, *Logistics for Joint Operations* for more details.

Protect

4.29. Air power projection relies on the protection of a network of operating bases, command, control, communications and information exchange networks and logistical nodes in the UK and around the world. Aircraft are scarce, expensive and fragile, and either operate from relatively large, static bases that are difficult to disguise, or from small, remote forward operating bases (FOBs) or forward arming and refuelling points (FARPs). Force protection is required to ensure the freedom of action to operate from such bases and to help mitigate against the strategic consequences that could arise from the loss of highly capable aircraft.⁷³

4.30. An early-entry force protection capability at the outset of an operation secures operating bases and enables the deployment of air power. Subsequent air operations are protected through coordinated activities and measures, both on the operating base and within any assigned ground defence area, established beyond the airbase perimeter fence. Successful force protection relies on a detailed understanding of how the airbase operates, its resident capabilities, and the local physical, human and information terrain that surrounds it.⁷⁴



Members of the RAF Regiment on a force protection exercise

⁷³ Since air power can be projected directly from the UK, force protection considerations apply equally to non-deployed capabilities.

⁷⁴ See Allied Tactical Publication (ATP)-3.3.6, *NATO Force Protection Doctrine for Air Operations*, for more detail on air force protection considerations and capabilities.

Section 4 – Employing air power in support of Defence Tasks

4.31. Following publication of the *National Security Strategy and Strategic Defence and Security Review 2015* (NSS/SDSR 2015), the UK Ministry of Defence (MOD) published *Defence Strategic Direction 2016*, which took the key themes from NSS/SDSR 2015 and distilled them into Defence Tasks. Set against the backdrop of the global and national context of the operating environment, as discussed in Chapter 2; the exploitation of the attributes, roles and command and control of air power, as discussed in Chapter 3; and the use of key air enablers, as discussed in Chapter 4, the employment of UK air power directly contributes to several Defence Tasks.

4.32. **Defence Task 1: Defence, Security and Resilience of the Homeland and Overseas Territories.** UK air power plays a critical role in supporting the defence of the homeland and Overseas Territories by maintaining the integrity of sovereign airspace and ensuring freedom of manoeuvre. Typhoon aircraft are on permanent standby in the UK and the Falkland Islands to provide national defence and security and to assure control of the air through combat air patrol or quick reaction alert. A robust system of command and control is a critical element of this, as are our allies, who help provide the necessary early warning. This task also covers support to UK civil authorities, where air power is employed in response to natural disasters, such as flooding, or to terrorist attacks.⁷⁵

4



A RAF Chinook and British Army soldiers support the Environmental Agency during flooding in the UK

⁷⁵ See JDP 02, *UK Operations: the Defence Contribution to Resilience and Security*, 3rd Edition, for more detail on air power's role in support to the UK civil authorities.

4.33. **Defence Task 2: Nuclear Deterrence and Defence Nuclear Enterprise.** This Defence Task is primarily focussed on the operation and protection of the UK's continuous at sea deterrent capability. Although details are classified, air power does provide a supporting role. Royal Navy air capabilities are employed in this capacity and NSS/SDSR 2015 committed to the renewal of a UK maritime patrol aircraft capability, through the purchase of P-8 Poseidon aircraft, which will be operated by the RAF. As well as providing significant input into other Defence Tasks, these aircraft can conduct specialist military data gathering in support of maritime operations, which deliver the nuclear deterrent.

4.34. **Defence Task 3: Understanding.** The requirement to understand underpins all of the Defence Tasks, as it provides the context, insight and foresight to inform timely decision-making. It also enables a more dynamic and scalable approach to the size, capabilities, posture and readiness states of air power. Through the ISR role, air power provides a full spectrum of capabilities to gather information which can then be fused with multiple sources, delivering the required understanding at the strategic, operational and tactical levels.

4.35. **Defence Task 4: Influence through international Defence Engagement.** This task includes Defence Engagement activity in support of wider cross-government objectives and priorities. It includes routine activities such as visits, training, exercises and permanent overseas exchange positions, for which air power plays a key role. It also includes opportunities, such as the part played by the RAF Aerobatic Team, the Red Arrows, who play a significant role in international engagement, through their numerous displays, conducted annually around the world, helping to fly the flag for broader Government initiatives overseas. Air power's speed of response in support of disasters, such as earthquakes, flood or famine can also generate a spirit of goodwill, or alleviate previously held grievances, therefore promoting security and stability. Consequently, this task contributes to gaining and preserving access and freedom of action by building alliances and partnerships, which is vital for air power projection.⁷⁶



Defence Engagement: the Red Arrows performing in China

76 As discussed in Chapter 4, Section 3, Basing; the reach of air power is largely dependent on access and overflight rights from other sovereign nations.

4.36. **Defence Task 5: Overseas Defence Activity.** This task concerns the provision of military capability to respond to political tension or crises overseas. Air power can be used to signal clear political intent through a range of measures, such as the overt deployment of combat aircraft to a particular region, or intensified peacetime training exercises. It can contribute to stabilisation, through the airborne insertion of personnel in a region where conflict threatens to spill over into neighbouring states. It can provide implicit deterrence, through the deployment of ISR aircraft to warn a potential aggressor that their actions are being watched and could provoke a response. Or ultimately, it can deliver rapid retribution deep into an adversary's territory, to deny an adversary the assurance that their homeland can be kept safe from an attack.

Influence through overseas Defence activity – Operation RUMAN

Operation RUMAN was the UK's military contribution to the international relief effort in the Caribbean Islands, which were left devastated by Hurricane Irma in 2017. Royal Air Force Voyager, C-17 and A-400M aircraft departed the UK within hours of the incident to provide immediate relief to people who had seen their homes destroyed. They carried over 300 UK military personnel, including 200 Royal Marines, engineers and specialist personnel from all three Services. Urgently needed medical supplies, emergency shelter kits, rations and clean water were also flown to the area. Puma helicopters were transported to the region to allow hub and spoke operations to be conducted from the UK joint task force base in Barbados. In addition, embarked in Royal Fleet Auxiliary Mounts Bay was a Royal Navy Wildcat helicopter, which was used to conduct reconnaissance flights of the area and more air power arrived within days onboard HMS Ocean. As well as satisfying the humane and moral requirement to help those in need, Operation RUMAN signalled the UK's support for the region, through a rapid response that was largely enabled by air power.

4.37. **Defence Task 6: UK Prosperity and Civil Society.** This concerns the promotion of the UK's economic security and opportunities globally. The MOD makes an important contribution to supporting the defence manufacturing industry, which in turn makes a significant contribution to UK prosperity. Air power directly supports the UK prosperity agenda through Defence Engagement opportunities overseas, in support of defence export programmes.

Key points

- Although air power is capable of independently achieving desired political objectives, it works most effectively when integrated with other components of military power.
- Through air power's flexibility and the speed with which it can reach the battlespace, it provides vital projection and sustainment, offering significant military advantage.
- The full spectrum approach to national power employs diplomatic, economic and military instruments of national power, all underpinned by information.
- Effective cross-environment integration depends on mutual trust and understanding, built on well-established bilateral cooperation between single Services.
- Large, complex, multinational air operations require a comprehensive command and control capability.
- The ability to deliver each of the four air power roles is dependent on critical enablers: base; sustain; connect; and protect.
- The employment of air power directly contributes to key UK Defence Tasks.





Part 2 – UK space power



Chapter 5

An introduction to UK space power

Chapter 5 provides an overview of space power, outlining its importance and utility in the contemporary operating environment. It introduces the attributes and roles and provides a definition of UK space power.

//

There is a **national ambition to gain and maintain a competitive edge in space.**

//

General Sir Gordon Messenger,
Vice Chief of the Defence Staff

Chapter 5 – An introduction to UK space power

5.1. The UK Government leverages three instruments of national power in pursuit of national policy goals, underpinned by information, these are diplomatic, economic and military instruments.⁷⁷ UK space power, along with maritime, land, air and cyber power, provide options for the use of the military instrument of national power. Space power makes a pivotal contribution to the potency of UK military power, both as an enabling domain and, increasingly, as an operating domain in its own right. It is also the domain which makes the most significant contribution to the effectiveness of all the instruments of national power.

5.2. UK military space capabilities are primarily coordinated and delivered by the Royal Air Force and Joint Forces Command. In the space domain, more than any other, the effectiveness of our space-enabled services and capabilities depends upon the strength of our multinational alliances and partnerships, as well as the expertise and support provided by the rapidly evolving UK civil and commercial space sectors.



© ESA

The UK as seen from the International Space Station

⁷⁷ See Joint Doctrine Publication (JDP) 0-01, *UK Defence Doctrine* for more details.

“
For over half a century, the most powerful states have exploited space in support of their national interests.
”

The utility of space power

5.3. For over half a century, the most powerful states have exploited space in support of their national interests. However, it was not until the first Gulf War that its potency as a critical military enabler was widely recognised. The increase in the number of satellites in the subsequent decades and the continued development of space-based sensors, resulted in space-enabled military capabilities becoming the norm. In the contemporary operating environment, space is central to the successful execution of military operations and has benefitted many aspects of modern life. It represents a source of power and influence in its own right and is therefore a critical weakness if not given appropriate protection from increasing threats.

5.4. Like air power, the attributes of space power are related to the ability to exploit the vertical dimension, albeit to a significantly greater degree, as space can provide a truly global capability. Users can take advantage of characteristics which offer significant utility across all levels of warfare: **perspective, access, persistence and versatility**. Such characteristics can help enable the delivery of military influence in support of national objectives. The UK recognises four space power roles.

- a. **Space situational awareness** underpins all other space roles and provides details of the hazards, risks and threats to the domain.
- b. **Space control** is the use of defensive and offensive capabilities to assure access and freedom of action in space.
- c. **Space support to operations** enables and enhances the effectiveness of other military and non-military capabilities.
- d. **Space service support** includes launch operations and support to space assets.

Space power and influence

5.5. Space power is defined as: **exerting influence in, from, or through, space**.⁷⁸ Diplomatic, military and economic credibility, together with a coherent strategy, play a large part in the ability to influence.⁷⁹ Power in either the diplomatic, military or economic sense is the currency that underpins the ability to influence, so without sufficient power, the ability to influence is limited.⁸⁰

78 This definition remains unaltered from the first edition of JDP 0-30, *UK Air and Space Doctrine*.

79 See JDP 04, *Understanding and Decision-Making*, 2nd Edition, for more details.

80 See JDP 0-01, *UK Defence Doctrine*, for more details.

5.6. Space power is inherently joint, because although it can be used to influence activities in space, it is primarily used to enable effects and exert influence in other domains. As such, UK space power makes a critical contribution to a joint approach to the application of military power, whereby scalable maritime, land, air, space and cyber forces operate together, within a single force. Such an approach offers policy makers a broad spectrum of military options.

The UK dependence on space

5.7. The vast majority of military operations could not be sustained without space capabilities. They are dependent on space, principally for communications, meteorological, positioning, navigation and timing (PNT) functions, as well as for intelligence, surveillance and reconnaissance (ISR). 'A day without space' would mean no effective strategic communications, the severing of direct command and control links with joint and coalition partners and a limited reachback capability, including the inability to operate unmanned or remotely piloted aircraft at range. It would also severely limit the ability to gather and disseminate intelligence and achieve precise effects across the battlespace.



Satellite communications provide a critical link between the UK and deployed forces

5.8. The UK, like all modern states, depends on space services, particularly PNT, for day-to-day societal functions, such as enabling banking transactions, the effective operation of the national power grid and the use of smartphones. So much so that space is an officially declared part of the UK's critical national infrastructure.⁸¹ However, the user is often unaware of this, making it difficult to acknowledge our reliance on freedom of access to, in and from the space environment.

5.9. The military element is only one component of the UK's space power capability, since space is also used to maximise the influence created through diplomatic and economic instruments of national power. A strong commercial space sector, allied space capabilities and civil and scientific expertise are all vital contributors to UK space power. In the context of this publication, although civilian and commercial capabilities will be included, the focus will be on the military aspects of space.⁸²



The effective operation of the national power grid is dependent on space services

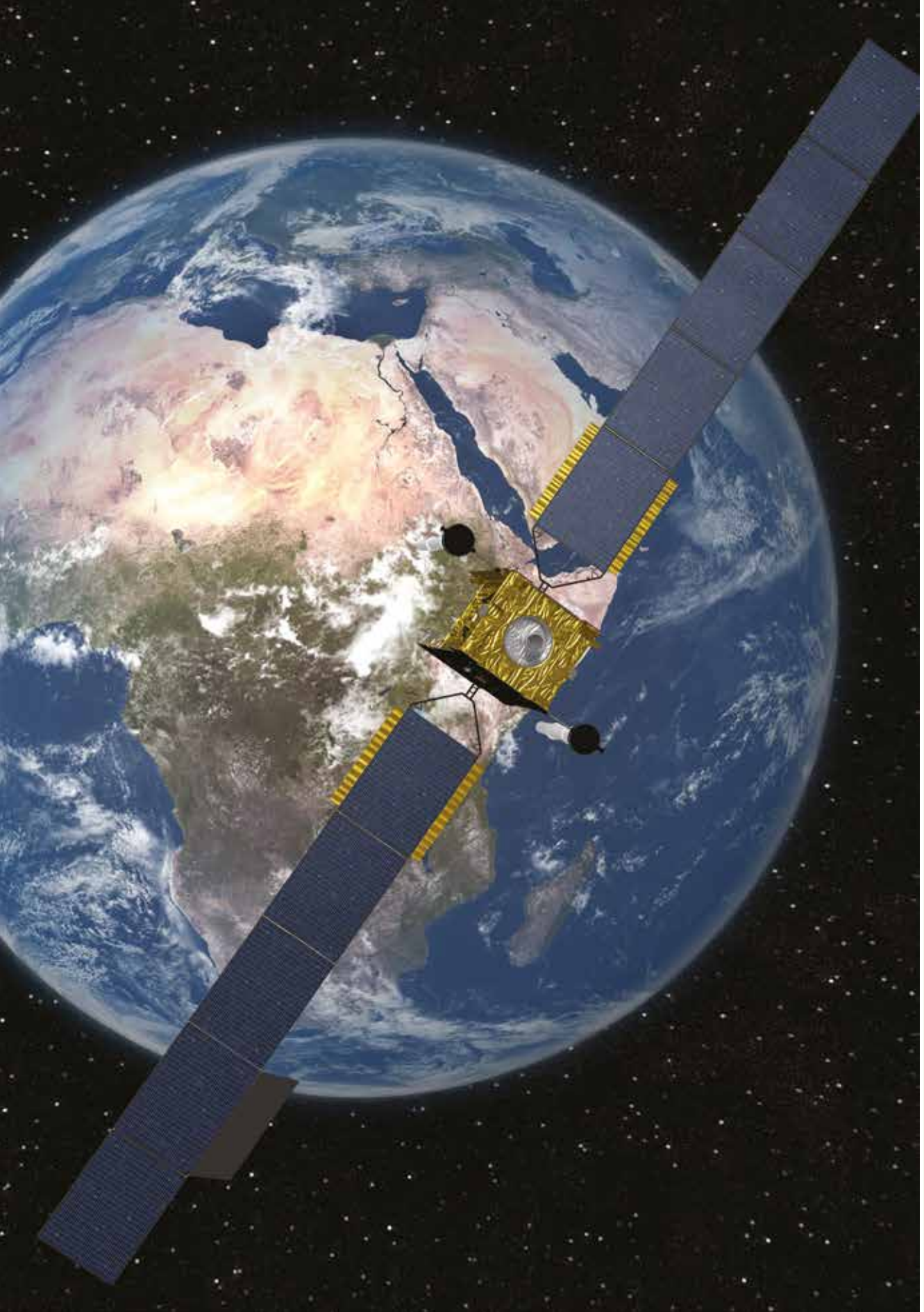
© Inteb Managed Services

81 In February 2015, Space was designated part of the critical national infrastructure (CNI) by the Centre for the Protection of National Infrastructure.

82 See *The UK Military Space Primer* for details on non-military aspects.

Key points

- Space power is defined as: exerting influence in, from, or through, space.
- UK space power, along with maritime, land, air and cyber power, form the interdependent levers of the military instrument of national power.
- Space power makes a pivotal contribution to the potency of UK military power, as an enabling environment and, increasingly, as an operating environment.
- Space is the environment which makes the most significant contribution to the effectiveness of all the instruments of national power.
- UK military space capabilities are primarily coordinated and delivered by the Royal Air Force and Joint Forces Command.
- The effectiveness of UK space-enabled services and capabilities depends upon the strength of our multinational alliances and on the UK civil and commercial space sectors.
- Space power is inherently joint because it can enable effects and exert influence in other domains.



Chapter 6

Space power in context

Chapter 6 outlines the factors that shape the space environment. It provides an overview of the global and national context within which UK space power is employed.

Section 1 – Aspects of the space environment . . .	79
Section 2 – The global context	84
Section 3 – The national context	85

//
Sixty years after Sputnik, this is a critical juncture in humanity's use of space.
//

Professor Frederick Lamb,
NASA advisor

Chapter 6 – Space power in context

Section 1 – Aspects of the space environment

Physical aspects

6.1. Just as air power is truly global in nature, so too is space. Depending on the orbit that they are placed in, satellites have the ability to overfly any point on Earth.

6.2. **Orbits.** Satellites move predictably according to fundamental physical laws, which determine the parameters of an orbit, including the period (the time taken for one complete orbit), the satellite's speed around the orbit and its track over the Earth. Figure 6.1 illustrates the most widely-used orbits; the choice of orbit is a compromise between the power required for data transmission against total area coverage on Earth; the period when a point on the Earth's surface remains in view of a satellite's antennae array; and the interval between repeat visits to specific points on the Earth's surface.

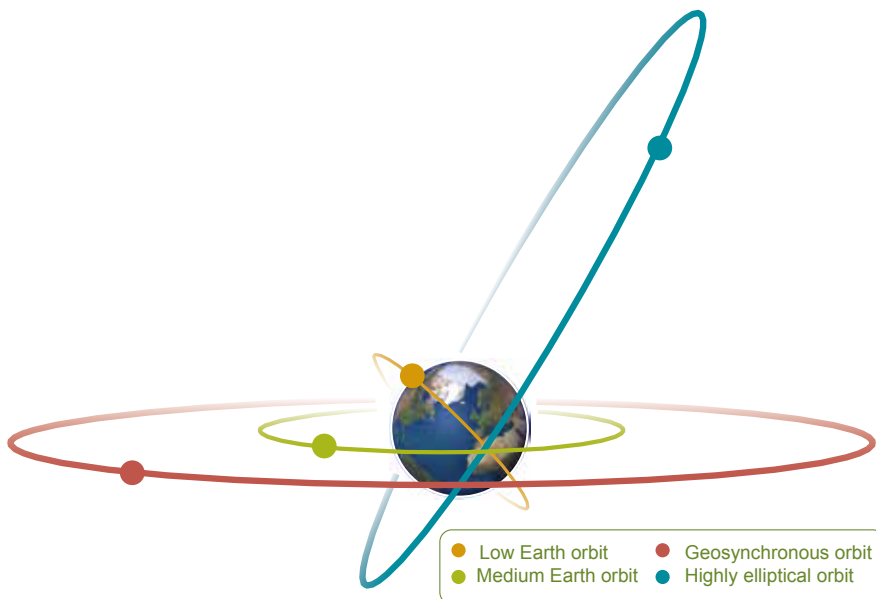
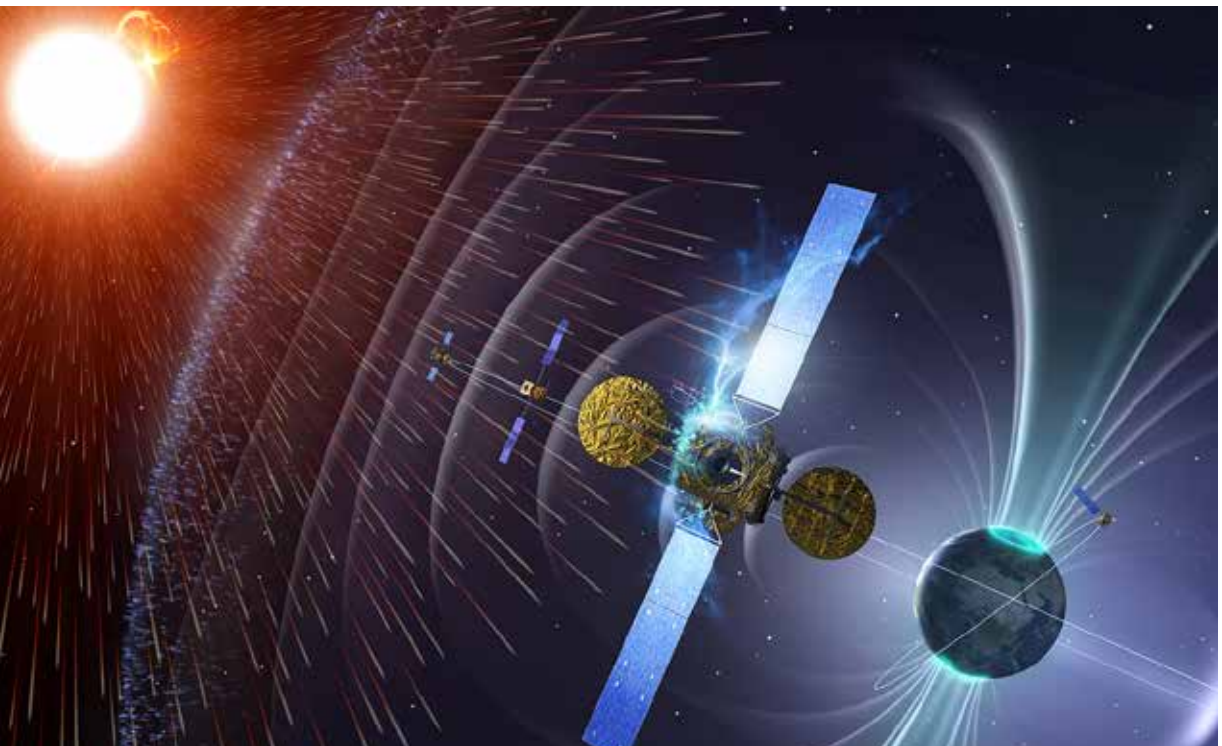


Figure 6.1 – The most widely used orbits

6.3. **Segments.** Unlike the maritime, land and air domains, space power is rarely enabled by human activity within the environment itself, but conducted through human activity on Earth. Consequently, space operations are separated into three segments to aid understanding of the areas of activity.

- a. **Space segment.** These are activities in the space domain.
- b. **Ground segment.** These are activities involving terrestrial assets, such as ground control stations.
- c. **Link segment.** These are activities, such as electromagnetic and cyber, that affect the signals linking the space segment with the ground segment.

6.4. **Space weather.** The sun's activity causes space weather, through events such as solar flares, coronal mass ejections and radiation storms.⁸³ Consequently, space is a harsh operating environment, due to high levels of radiation, highly energetic particles, fluctuating magnetic fields and extremes of temperature. Such hazards can cause significant electromagnetic interference, which can then severely impact military capabilities.



Space weather, such as solar storms, can have a negative impact on satellite performance

⁸³ See the *UK Military Space Primer* for more details.

6.5. **Impact of space weather.** Space weather can adversely affect space segment capabilities, by disrupting satellite sensors, degrading electronic circuits, corrupting computer memory and by causing damage to solar panels. Enhanced radiation levels also heat the atmosphere, subjecting satellites in low Earth orbit to enhanced drag, which shortens their lifetime. Space weather can affect the link segment, since solar storms have the capacity to disrupt communication and navigation system frequencies.⁸⁴ It can also create effects on Earth, causing damage to electrical systems such as power grids, pipelines and signalling equipment. Space weather can therefore have a significant impact on a host of military and civilian applications, such as satellite communications and precise navigation. Users of systems that have a dependency on space need to be cognisant of the dynamic space environment and satellites need to be resilient enough to operate effectively in such an environment.

Space weather – Operation ANACONDA

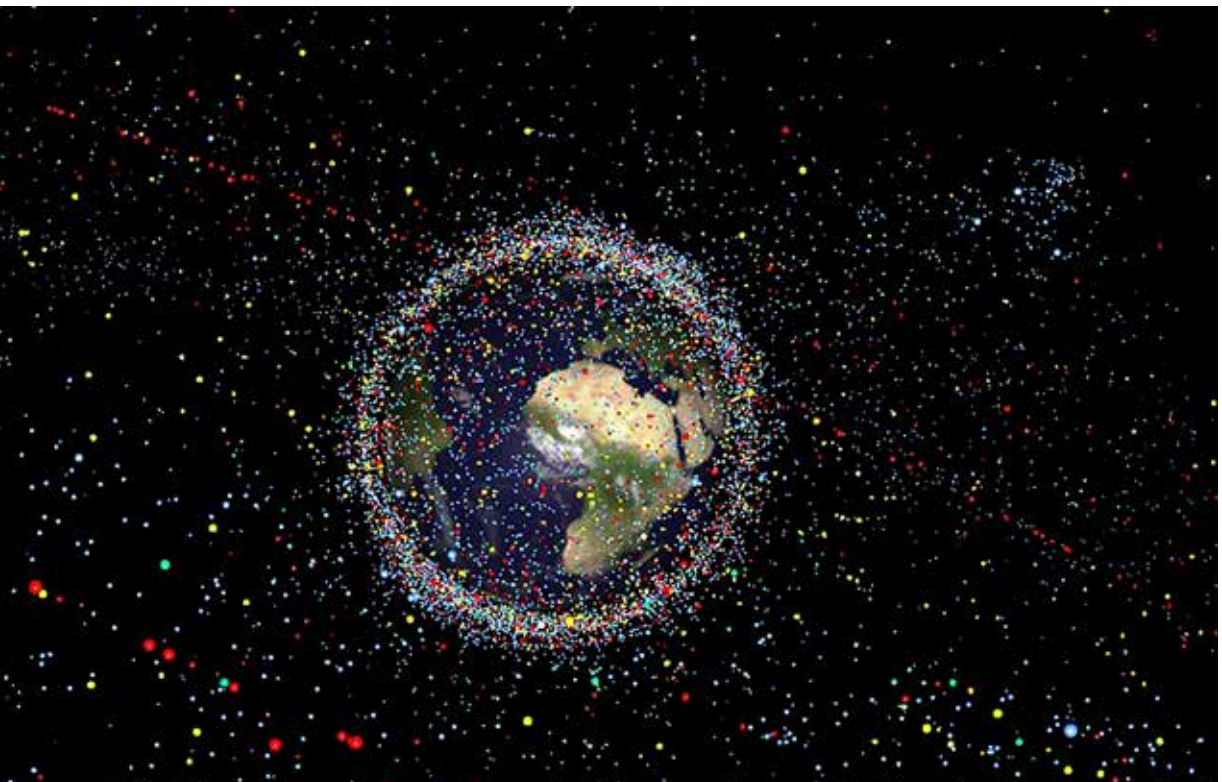
At approximately 0300 on 4 March 2002, the Taliban shot down a United States (US) Chinook helicopter in the mountains of Afghanistan as it attempted to rescue a team of US Navy SEALs. Command and control elements at Bagram Air Base had tried to contact the Chinook crew to warn them not to attempt a landing on the peak of Takur Ghar as it was overrun with enemy forces. Having failed to receive the warning, the Chinook crash-landed after being hit by enemy fire and US lives were lost in the subsequent firefight.

A team of researchers claimed that space weather may have contributed to the breakdown in communications, due to the phenomena of ‘plasma bubbles’, which can form in the upper atmosphere after nightfall. Stretching up to 100km wide, they are thin clouds of electrically charged gas particles which can disperse, reflect, refract or attenuate radio waves. Analysis of data gained from a satellite which overflew the battle area at the approximate time of the incident, confirmed the existence of a huge plasma bubble between the Chinook and the communications satellite that was trying to relay the urgent warning message. Although not proof of the root cause of the incident, it is possible that this may have been a contributing factor to the communications outage.

.....
84 Including secure satellite communications and positioning, navigation and timing data, derived from the Global Positioning System (GPS). These subjects are discussed in more detail in Chapter 7.

6.6. **Space debris.** There are tens of thousands of objects in orbit larger than 10cm, most of which are items of space debris.⁸⁵ The total amount of debris, most of which is too small to be detected, is estimated to be greater than one hundred million objects.⁸⁶ Such a relatively large amount of debris is a significant hazard to operating in the space domain and it is constantly increasing.

6.7. **Debris removal.** Removing debris is technically possible but it is complicated by cost, legal and political challenges. An effort by one state to remove a non-functioning object owned by another could be interpreted as a hostile act and raise wider security concerns. Space debris continues to be a significant issue, hence the requirement for capabilities to track and monitor such hazards and risks.⁸⁷



An artist's impression of the distribution of space debris around the Earth

© ESA

85 The UK is a world leader in orbital debris research.

86 For more information see http://www.esa.int/spaceinimages/Images/2013/04/Distribution_of_debris.

87 This is discussed further in Chapter 7.

Legal aspects

6.8. Aircraft flying over a particular state operate within its sovereign airspace and are therefore subject to national jurisdiction and sanction. In contrast, like the vast majority of the maritime environment, space is considered to be part of the global commons; the concept of territorial sovereignty does not apply in space. As a result, spacecraft and satellites are not restricted by national boundaries. The principle that outer space is not subject to national appropriation by claim of sovereignty is enshrined in the *1967 Outer Space Treaty*, which is the foundation of international space law.⁸⁸

6.9. The treaty declares space to be the province of all mankind, free for exploration and use by all nations, and places international responsibility on the state for its national space activities. It also places liability on the launching state for any damage caused by space objects.⁸⁹ Military activities are allowed but there are constraints, for example, military bases, weapons tests or military manoeuvres are not allowed on the moon or any other celestial bodies. *The Outer Space Act 1986* is UK legislation that regulates national space activities, including the launch and operation of space objects.

Economic aspects

6.10. Recent advances in technology are changing the economics of operating in the space domain. Certain space capabilities, such as small satellites, are becoming more affordable. Additionally, space-derived services such as satellite imagery is now commercially available and can be bought at relatively low cost. Consequently, space is no longer an operating domain reserved for use by the wealthiest nations.⁹⁰ As a result, many states now enjoy access to space capabilities, even if they rely on other states for space launch services.

88 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, available at <http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html>

89 For a description of a launching state see the United Nations Office for Outer Space Affairs, *Convention on International Liability for Damage Caused by Space Objects*. Available at <http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/liability-convention.html>

90 There is an increasing ability to use 'off-the-shelf' components within satellites, rather than materials that have gone through expensive, protracted laboratory testing to ensure space-worthiness. A prime example is the STM Sat-1 satellite, which was deployed from the International Space Station in May 2016.

“
Recent advances
in technology
are changing
the economics
of operating
in the space
domain.
”

Section 2 – The global context

“ Since all states share the space environment, it is uniquely positioned to encourage cooperation. ”

6.11. Since all states share the space domain, it is uniquely positioned to encourage cooperation. A broad multinational and multi-agency collaboration, including allies, international organisations and non-governmental organisations, can provide a range of services that most nations could not generate independently. Working together with international partners in the space domain also helps solidify collaboration in wider security, defence and intelligence matters.

6.12. Even though the costs of a variety of space capabilities are becoming more affordable, costs associated with some space programmes can be prohibitive for all but the most powerful states. The UK therefore seeks collaboration opportunities to share the infrastructure and associated costs.⁹¹ As our pre-eminent national security partner, cooperation with the United States (US) is exceptionally close and the relationship is critical to assure access to a host of space services. Conversely, the UK operates a limited number of space capabilities which bring mutual benefit to this relationship.

6.13. The North Atlantic Treaty Organization (NATO) has an important role in building recognition of the security risks and opportunities associated with space. The UK supports this work, helping to develop thinking on space and identify space-related vulnerabilities and ways of mitigating them, in the interests of maintaining a resilient alliance. The UK also works closely with European partners to ensure best practice is followed in the security of European space programmes, as well as the Five Eyes community, through endeavours such as the Combined Space Operations (CSpO) initiative.⁹²

6



The main control room at the European Space Agency's Space Operations centre, in Darmstadt, Germany

© ESA

91 The UK National Space Policy, Page 14.

92 The Five Eyes community consists of Australia, Canada, New Zealand, the United Kingdom and the United States of America.

Section 3 – The national context

6.14. UK space capabilities are inherently dual-use in nature given that the same environment, largely the same technology and often the same infrastructure is used to meet both military and civil operations. Space services play a pivotal role in contributing to UK national security, the strength of the economy and the delivery of public services.⁹³ Consequently, the impacts of an extreme space weather event are captured as a Tier 1 risk on the National Risk Register, and the loss of information provided by satellites is categorised as a Tier 2 National Security Risk.

6.15. More than any other environment, space cuts across a number of UK Government departments. The Ministry of Defence uses satellite services space-enabled services in support of global military operations, from disaster relief response to the employment of precision weapons. The Department for Environment, Food and Rural Affairs uses satellite data for its environmental management programmes and the Home Office uses space-enabled capabilities for critical emergency services and law enforcement activities. The *National Space Policy* clearly articulates cross-government reliance on space-enabled capabilities.

6.16. The UK commercial space sector makes a vital contribution to the economy, generating billions of pounds each year.⁹⁴ The development of satellites in particular is recognised as one of the eight great emerging technology sectors that support the economy. However, the true economic value of space is significantly larger when the services enabled by it are taken into consideration, including agriculture, energy, meteorology, telecommunications, aviation



⁹³ Severe disruption to information received, transmitted or collected by satellites could pose a significant security risk to the UK. The *National Space Security Policy* and the *National Security Strategy* provide more detail on the link between the UK's reliance on space and its potential to impact security.

⁹⁴ See the *National Security Strategy and Strategic Defence and Security Review 2015* (NSS/SDSR 2015), Chapter 4.150 for more details.

and maritime transport.⁹⁵ The UK is therefore reliant on space access not only for national security interests but also for economic prosperity.⁹⁶

Key points

- The space environment is split into three segments: the space segment, the ground segment and the link segment.
- The sun's activity causes 'space weather', which can adversely affect space, and military capabilities.
- Space contains tens of thousands of pieces of space debris, which can be hazardous to space operations.
- Space is considered to be part of the global commons, so spacecraft and satellites are not restricted by national boundaries.
- Since all states share the space environment, it is uniquely positioned to encourage cooperation.
- UK space capabilities are inherently dual-use, given that the same capabilities and infrastructure can be used to support both military and civil operations.
- The UK commercial space sector makes a vital contribution to the economy, generating billions of pounds each year.

95 It has been estimated that the UK Space Industry derived a turnover of £1.7bn from positioning, navigation and timing (PNT) services in 2014/15, supporting 4,000 jobs. More broadly, sectors generating a total of £206billion in gross value added (11.3% of UK gross domestic product) are supported directly by space-based PNT services. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/619545/17.3254_Economic_impact_to_UK_of_a_disruption_to_GNSS_-_Showcase_Report.pdf.

96 NSS/SDSR 2015, Chapter 3.30.

Notes



The foundations of space power

Chapter 7 provides an overview of the attributes and roles of space power. It highlights which UK space capabilities contribute to the various missions within the separate roles.

Section 1 – The attributes of space power 91

Section 2 – The roles of space power 92

//

No-one wants a conflict that extends into space, but we must be prepared for when and if it does.

//

General Hyten,
Commander, United States Strategic Command

Chapter 7 – The foundations of space power

Section 1 – The attributes of space power

7.1. Space power has distinctive attributes brought about by the characteristics of the environment. The attributes of space power are **perspective, access, persistence and versatility**.

7.2. **Perspective.** As with the air domain, space capabilities exploit the vertical dimension, albeit to a completely different order of magnitude. Such an unparalleled vantage point means that space represents the ultimate high ground. Even satellites stationed in the lowest orbits offer a footprint which can cover thousands of square miles of the Earth's surface. Those positioned in the higher orbits can have a perspective covering approximately one third of the Earth.

7.3. **Access.** The international rules and norms governing overflight of sovereign states by aircraft do not apply to satellites; space offers unrivalled access to any point on Earth, with no requirement to adhere to national boundaries. This provides significant military utility, as satellites can overcome the difficulties of gaining access to an area of operation, be it due to overflight permission or adversarial anti-access and area denial (A2AD) strategies.⁹⁷

7.4. **Persistence.** Typically, the orbit life expectancy of satellites is measured in years or even decades, so they can overcome the air power limitation of impermanence. The geostationary orbit allows a satellite to remain over the same area of the Earth 24 hours a day, providing continuous access to a given terrestrial area of interest. Satellites in lower orbits can also provide significant persistence, if sufficient coverage is provided by a constellation of satellites. However, the higher geostationary orbit does not afford high resolution images of Earth and individual satellites in lower Earth orbit can only provide intermittent coverage.

.....
97 Satellites are not impervious to anti-access and area denial (A2AD) threats, as demonstrated by a successful anti-satellite missile test by China in 2007, which is discussed later in this chapter. However, the perceived constraints on satellite operations is very much reduced compared to air operations.

7.5. **Versatility.** Space assets are versatile because a single platform can carry a multitude of sensors and capabilities to provide services simultaneously to multiple users. Most UK space programmes are combined civil-military enterprises, with broad applicability across a range of government policy functions.

Section 2 – The roles of space power

7.6. The four roles of space power provide a basis for understanding the enabling and operating characteristics of the domain. To facilitate efficient cooperation and common understanding with our most significant space partner, they broadly reflect the United States’ (US) roles of space power.⁹⁸ The four roles are illustrated in Figure 7.1.

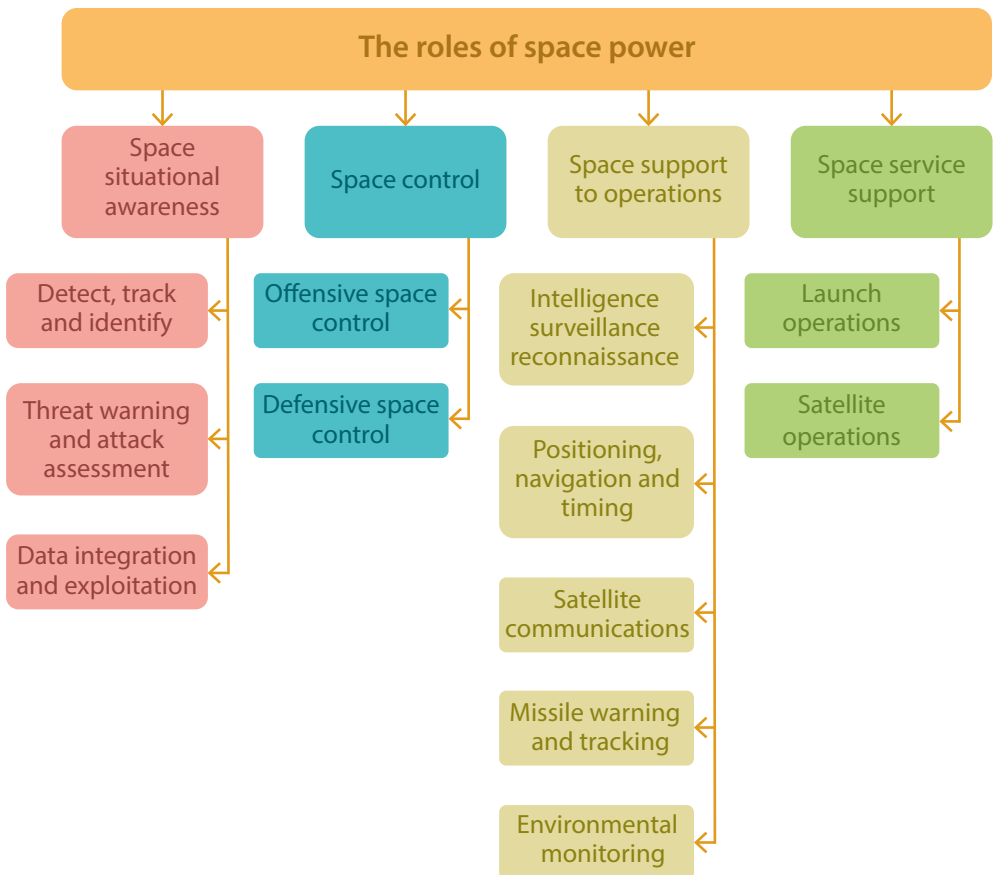


Figure 7.1 – The roles of space power

⁹⁸ The United States (US) space role of ‘Battle Management Command and Control’ is not conducted by the UK. See US Joint Publication 3-14, *Space Operations*, for details on US space operations.

Space situational awareness

7.7. Space situational awareness (SSA) underpins all other space roles, as it provides an understanding of the space environment. It enables the timely assessment of and response to space threats, risks and events, both natural and man-made. It is broken down into four core functions: detect, track and identify; threat warning and attack assessment; characterisation; and data integration and exploitation. These are shown in Figure 7.2.

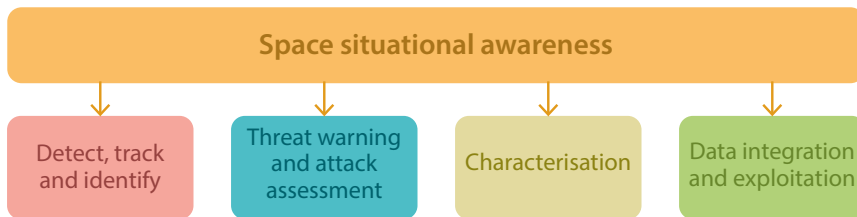


Figure 7.2 – The core functions of space situational awareness

- a. **Detect, track and identify.** This is the ability to detect, track and identify space objects and events and recognise them as belonging to certain mission types; a key capability which is used to develop a common operating picture for decision-makers. It is also one of the means by which the UK fulfils its international obligations by monitoring objects licenced for launch by the UK. The detect, track and identify function is enabled by various sensors across the electromagnetic spectrum, such as the Solid-State Phased Array Radar at RAF Fylingdales⁹⁹ and the civil sensors at Hertsmonceux.¹⁰⁰
- b. **Threat warning and attack assessment.** This is the ability to predict and differentiate between potential or actual hazards and threats, be they from space weather, space debris or attacks by adversaries. Terrestrial sensors predict potential impacts and subsequently provide warnings to satellite operators to avoid collisions between satellites and/or space debris.¹⁰¹ With regard to adversarial activities, this function aims to identify the actors involved and the type of activities that are being conducted. In doing so, it can also support a wider deterrence posture by enabling the attribution of offensive actions in space. The UK Space Operations Centre (SpOC) at RAF

⁹⁹ The facility at RAF Fylingdales is a joint enterprise between the UK and the US.

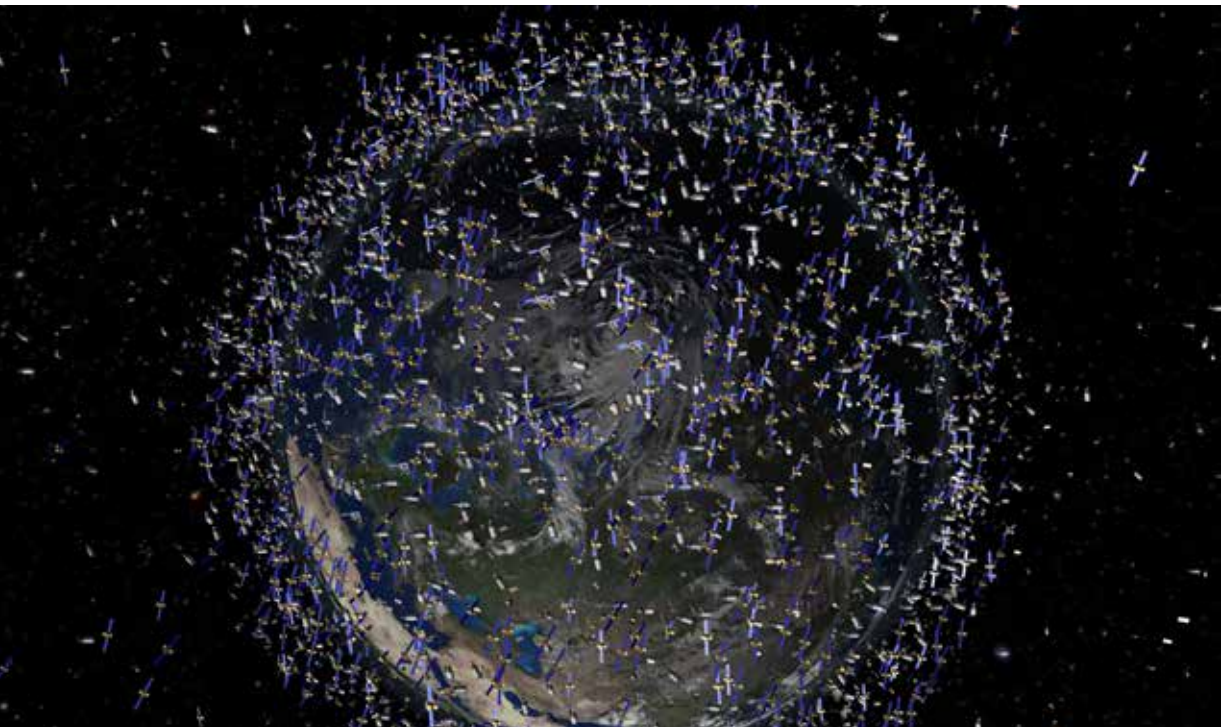
¹⁰⁰ There is an aspiration for future, national capability integration for space situational awareness (SSA), which will incorporate current and future sensors. Refer to the *Defence Space Strategy* for more details; to be published in 2018.

¹⁰¹ The prediction of potential collisions is referred to as conjunction analysis. For more details, see *The UK Military Space Primer*.

High Wycombe,¹⁰² provides the UK threat warning and attack assessment capability, in coordination with RAF Fylingdales and other government agencies and industry partners, such as the Met Office's Space Weather Operations Centre (MOSWOC) for space weather events.¹⁰³

c. **Characterisation.** Once threats or hazards have been detected, tracked and identified, a more detailed analysis can provide a level of characterisation. In relation to potential threats, characterisation is the ability to determine strategy, tactics, intent and activity of the satellite including the characteristics and operating parameters of the satellite. This provides decision-makers with the knowledge and confidence to make assessments of which space capabilities or natural events may impact their operations.

d. **Data integration and exploitation.** Data integration and exploitation is the ability to fuse, correlate and integrate multi-source data from military, commercial and allied sources into a usable common operating picture. It is this capability which enhances the other functional areas of SSA, to enable decision-making for all space operations.



An artist's impression of space debris and satellites orbiting the Earth provides an indication of the complexity of the space situational awareness role

© ESA

102 In consultation with the US Joint Space Operations Centre (US JSpOC).

103 Operational since October 2014, the Met Office operates a fully manned Space Weather Operations Centre, which issues space weather forecasts, alerts, warnings and advice 24 hours a day.

Space control

7.8. Space control involves affecting adversary space capabilities as well as assuring our own access to space. The nature of the space environment is such that total control is not feasible for any single actor; space dominance has little relevance, given the scale and scope of the environment. However, it is necessary to achieve sufficient control to assure freedom of action in space. Space control is split into two key components: offensive space control and defensive space control. These are illustrated in Figure 7.3.

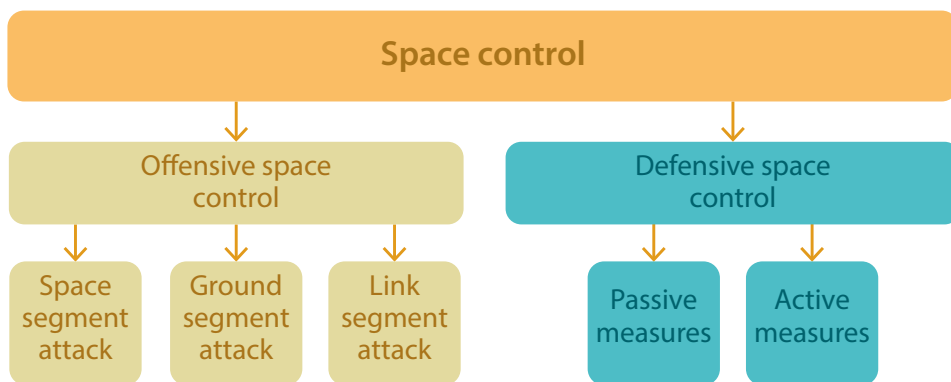


Figure 7.3 – The components of space control

7.9. **Offensive space control (OSC)** operations seek to disrupt, degrade, deny or destroy the space-related capabilities and forces of an adversary. Such operations can be targeted against the three distinct segments of space activities – the space segment, the ground segment or the link segment.

- a. Space segment attack consists of systems and activities used to disrupt, degrade, deny or destroy a satellite. Co-orbital attack systems can position an interceptor satellite into a similar orbit to the target satellite, which can then be used to physically manipulate or damage it. Alternatively, a satellite could approach another satellite and use a robotic arm to manually snap off its communications antennas, destabilise its orbit, or simply be positioned in order to block line-of-sight.¹⁰⁴ Direct ascent weapons, launched from the maritime, land or air domains aim to hit a satellite.¹⁰⁵ Non-kinetic means of

104 Debris removal technologies could be dual-use technologies, as an adversary could develop an OSC capability, able to 'capture' target satellites, under the cover of a debris mitigation programme.

105 The US, Russia and China have all demonstrated that they have the ability to conduct direct ascent attacks on satellites.

space segment attack can include laser-dazzle attack or using electronic warfare techniques.

Direct ascent attacks

On 13 September 1985, the US Air Force successfully test-fired an anti-satellite missile from an F-15 Eagle aircraft, from Edwards Air Force Base, California. The test was successful; the missile successfully destroyed a US satellite orbiting 340 miles overhead.

On 11 January 2007, China launched a direct ascent attack on one of its own defunct weather satellites, the FY-1C Fengyun. This was the first known incident of its kind since the US test in 1985. The event demonstrated to the world that China had the ability to target a satellite, and could therefore contest control of space.

Laser dazzle attacks



This image shows a ground station 'laser-tagging' the moon, as part of tests for a future satellite communications capability. Although not linked to an offensive space control capability, it pictorially demonstrates the use of lasers in space and provides an indication of the disruptive effects that could be achieved with a significantly more powerful laser, used in conjunction with advanced satellite tracking capabilities.



© ESA

Terrestrial space facilities can be vulnerable to ground segment attack

b. Ground segment attack is a practical option for OSC operations, since it can be delivered through a kinetic attack on a terrestrial space node, such as by a combat air platform, cruise missile or by special forces attack. Alternatively non-kinetic means, such as electronic warfare or cyber attacks can be used. Such methods avoid the advanced technological requirements and costs associated with a kinetic attack on the space segment, as well as avoiding the unwanted generation of space debris.

c. Link segment attack targets a satellite's control and data transmissions by attacking the links with its terrestrial control or receive nodes, via non-kinetic means, such as electronic warfare or cyber attacks. Electronic attack can use either space or land-based jamming or spoofing techniques to target a satellite through signal interference. Cyber attacks can target satellite control systems, potentially allowing an adversary to take control and either disable it or manipulate the satellite to their advantage, such as shifting the focus of the sensors to another area.

7.10. **Defensive space control (DSC)** is proactive in nature and is conducted to protect space capabilities from attack, interference or unintentional hazards.

Various methods can be used to ensure space capabilities have adequate resilience to disruption from malicious activity or space weather. Foreign counter-space programmes are becoming increasingly capable, so defensive capabilities must continue to be developed to assure freedom of action. Defensive space control consists of both passive and active measures.

- a. **Passive measures** provide a significant level of protection by physically hardening satellites to enable resistance to radiation or electronic attack. Anti-jamming and cryptographic techniques can be used to protect command, telemetry and data transmission links. The protection of terrestrial infrastructure is another important aspect and can be done by ensuring that adequate force protection is in place, or by using camouflage, concealment and deception techniques.
- b. **Active measures** include the use of techniques to counter any adversarial jamming or interference to satellite control signals. If a threat is aimed directly at the satellite or the sensor, its orbital position can be adjusted to counter the threat, or shield the sensor from interference and attack. However, manoeuvring an existing satellite into a new orbit shortens its operational life, as its fuel supply cannot be replenished. Such a response will also alter the ground track of the satellite, which may ultimately degrade its mission.



Satellites need to be resilient to adversarial activity as well as natural factors such as space weather

7.11. **Challenges to space control.** Satellites typically follow predictable orbits, are difficult to conceal and have a limited ability to manoeuvre away from threats. This makes them vulnerable to adversaries who have the ability to track and subsequently target them using OSC techniques, such as laser dazzling or, *in extremis*, a kinetic attack.¹⁰⁶ However, this can be mitigated by fitting high efficiency thrusters or drag augmentation devices to satellites, which can reduce the predictability of their orbits. The use of alternative surface properties can also complicate efforts to observe and track satellites.

7.12. Satellites are highly dependent on the link segment for control and data transmission, so adequate encryption and anti-jamming capabilities must be used to prevent them from being exploited. However, these measures come at a cost, and some commercial or dual-use capabilities may not be suitably secure, which could affect access to space capabilities.

Space support to operations

7.13. Space support to operations enables and enhances UK military capabilities, providing critical support to the combat effectiveness of the joint force. It is divided into five core functions, as shown in Figure 7.4.¹⁰⁷

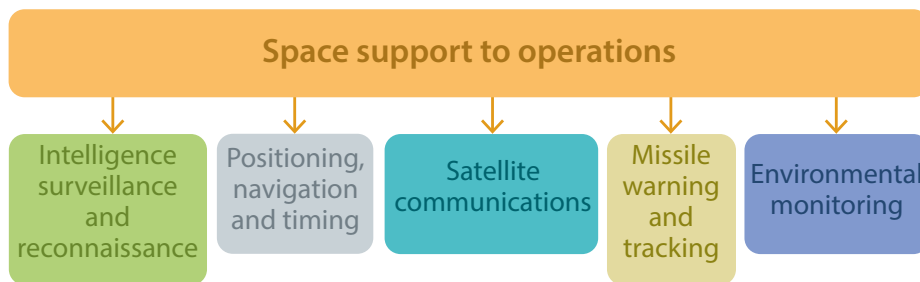


Figure 7.4 – Space support to operations

7.14. **Intelligence, surveillance and reconnaissance.** The perspective offered by space enables intelligence, surveillance and reconnaissance (ISR) satellites to cover an unmatched area of interest. They can be focussed over a wide area or on a specific point of interest and conduct a number of ISR tasks, including passive imagery and electronic intelligence gathering. Advanced sensor technologies have resulted in satellites being able to produce images of a resolution that can match or even

106 Conversely, the orbit of adversary satellites can also be predicted, enabling the conduct of offensive space control activities or the concealment of sensitive operations or capabilities on earth, to deny any potential monitoring by an adversary.

107 The US recognises and participates in a sixth function: navigation warfare. See US Joint Publication 3-14, *Space Operations* for more details.

eclipse those provided by some air platforms. Despite the potential threat of OSC capabilities, ISR satellites may enable access to hostile areas, which are impenetrable to ISR aircraft. This creates opportunities for fusing complementary capabilities, whereby satellites can plug gaps in air-based ISR and *vice versa*.

7.15. High resolution electro-optical and synthetic aperture radar imagery is now commercially available, with civilian assets capable of producing images of a quality that was previously only available at a classified military level. Commercial products therefore have the potential to plug gaps in capability or supplement over-tasked allied military capabilities, which may be an option for potential adversaries.

7.16. **Challenges to intelligence, surveillance and reconnaissance.** The global presence offered by ISR satellites means they can offer an immediate response to a crisis to help build understanding. At the very least, they are likely to be first on the scene. However, their responsiveness, as well as being a strength, can also be limited. Large constellations of ISR satellites can offer significant resilience but there could still be gaps in coverage. It is therefore important to consider whether an area of interest can be covered, for how long and for how often, over a given period of time. This depends on the orbit of the satellite, which may limit responsiveness and coverage time during each orbit over a specific point.¹⁰⁸



An intelligence, surveillance and reconnaissance satellite image of the UK

108 Any orbit represents a compromise between imagery resolution and the dwell time of the satellite. However, depending on the specific task, a low resolution image from a satellite in a higher orbit might be mission effective.



© ESA

Satellites can often only cover a specific area of interest for a short period of time

7.17. Large and exquisite sensors are built to specific requirements and timelines for construction are considerable, so reconstitution of assets can take time – this means that resilient architectures and collaborative arrangements are key for the current and likely future contested environment. Reconstituting a lost capability can also be a long-term project, due to the length of time it takes to build a satellite and the limited launch windows available. However, operationally-responsive emerging technologies may offer options to meet shortfalls in coverage, through the relatively rapid deployment of small-satellites.¹⁰⁹

7.18. **Positioning, navigation and timing.** Space-derived positioning, navigation and timing (PNT) capabilities provide mission-essential data and information, enabling the effective execution of military operations. It provides precision navigation for military platforms and personnel; precision guidance for smart weapons; and precision timing for datalinks and secure communications. It gives the joint force the ability to effectively synchronise operations, whilst ensuring communications security. The MOD makes use of the US Global Positioning System (GPS), which provides position, velocity and time information to an unlimited number of users, through civilian and encrypted military modes. The timing signal is particularly essential for secure communications and data transfer capabilities, such as datalinks.

.....
109 The UK is a world leader in small-satellite technology.

7.19. **Challenges to positioning, navigation and timing.** Although the GPS signal can be encrypted for military use, the technique used to transmit GPS data means that the power of the received signal is very low. Consequently, the GPS signal is susceptible to jamming and even a low power jammer can prevent the receipt of GPS signals across an area of several square kilometres. The potential for jamming is well recognised, so work to combat this limitation is ongoing. Its potential loss can also be mitigated by reducing the dependency on the system, by developing capabilities and procedures that do not rely on space-derived PNT services. Although the majority of UK military capabilities will continue to rely on GPS in the near term, alternative Global Navigation Space System (GNSS)¹¹⁰ capabilities are being pursued to improve resilience. The UK is one of the lead developers of technology associated with the European Galileo GNSS.¹¹¹

7.20. **Satellite communications.** The ability to communicate beyond line-of-sight is an essential military requirement, since terrain or horizon-masking can restrict radio communications. Satellite communications (SATCOM) relay data and voice transmissions through space, providing the ability to establish communications at any point on the globe. It enables secure communications between UK home bases and deployed forces, even in austere locations with poor infrastructure. It also enables the dissemination of operationally critical ISR data and the control of unmanned or remotely piloted aircraft systems at range. The global reach and effectiveness of UK Armed Forces is therefore dependent on resilient SATCOM.

7.21. **Bandwidth.** The UK's secure SATCOM capability is provided through a private finance initiative with Airbus, which is managed by Joint Forces Command. It provides a secure and resilient communications capability through the Skynet¹¹² series of satellites and other SATCOM resources from other providers. UK partners and allies also use Skynet bandwidth, which bolsters collaborative ties and similarly, lost or degraded capabilities can be replaced by negotiating access to their space services. Commercial bandwidth can provide redundancy for military systems but there are potential security risks if military communications are enabled by commercial satellites, which could also host foreign payloads. There are also risks in using commercial bandwidth because the terms of service provision could be significantly less than that provided through a dedicated military system.

.....
110 Global Navigation Space Systems (GNSS) is the umbrella term for space-based PNT capabilities.

111 The *National Security Strategy and Strategic Defence and Security Review 2015*, para 4.153.

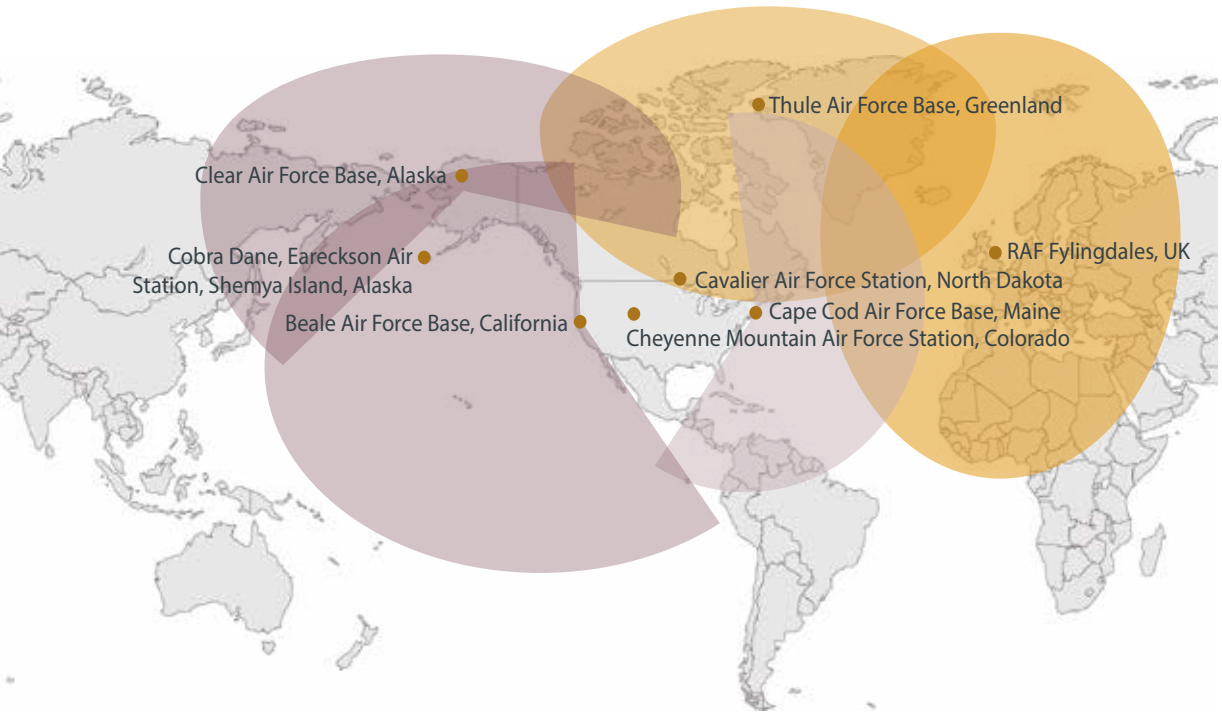
112 Skynet is a family of military communications satellites, operated on behalf of the Ministry of Defence. Skynet-4 and 5 satellites are operational and the replacement, Skynet-6 is under development.

7.22. **Missile warning and tracking.** A network of missile warning and tracking systems provide global coverage to track ballistic missile launches and flight paths, and predict likely time and point of impact. Ground-based systems such as the ballistic missile early warning and tracking system at RAF Fylingdales feeds into a US global system and provides a significant input into the missile warning function. The UK SpOC works closely with RAF Fylingdales to ensure that missile warning details are disseminated. The US space-based infra-red system (SBIRS) provides a space-based ballistic missile warning and tracking capability, the output from which is shared with allies, including the UK.



© ESA

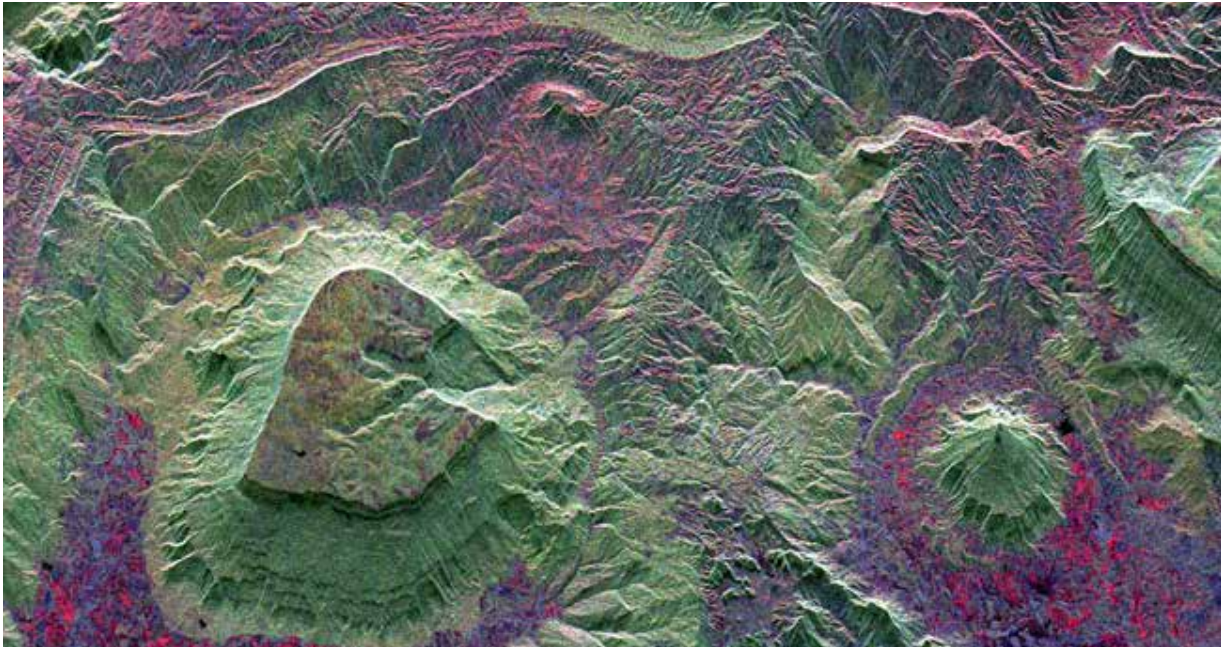
A missile warning satellite being launched into space, which will be able to detect similar rocket launches



An approximate representation of the coverage provided by RAF Fylingdales and other ballistic missile warning facilities

7.23. Space-based missile warning is just one component of a capability that must also integrate layers of surface-based sensors and interceptors. Ballistic missile defence must therefore be considered as part of a broader, cross-domain air and missile defence system.

7.24. **Environmental monitoring.** Data derived from space assets can provide information on meteorological, oceanographic and environmental factors that may affect the planning and execution of military operations, be it from space weather or terrestrial weather. Synthetic aperture radar capabilities can track weather fronts and provide data on ocean waves and a variety of multispectral capabilities can measure humidity, cloud cover and the composition of terrain materials. Space-derived terrestrial weather monitoring also contributes to a significant proportion of long-range weather forecasting. This function is therefore a key enabler, as it provides operationally significant information on sub-surface, surface, and air conditions, which has utility for multiple operations in the maritime, land and air domains.



© ESA

A synthetic aperture radar image with colours assigned to different radar frequencies to help understand terrain composition – a useful capability for land operations

Space service support

7.25. Space service support consists of operations that launch space assets and maintain and sustain them. It comprises launch operations and satellite operations as illustrated in Figure 7.5.

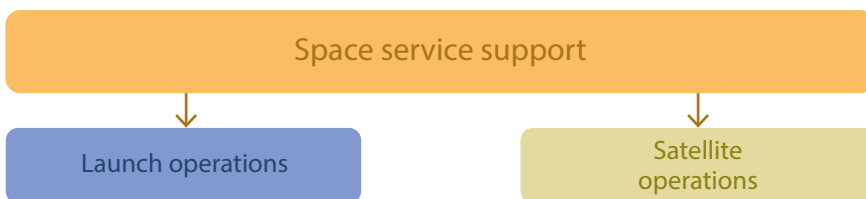


Figure 7.5 – Space service support

7.26. **Launch operations** are fundamental to the ability to participate in space-based activities as they deliver satellites, payloads and material into space. Due to the associated cost of this activity, the UK has historically relied on allies and third-party launch capabilities such as the US, India and the European Space Agency to deliver UK satellites into orbit.



A UK Skynet 5D SATCOM satellite being launched from French Guiana

© Airbus

7.27. **Satellite operations** involve the manoeuvring, sustainment and maintenance of satellites. The Ministry of Defence depends on commercial providers for this function, demonstrating that military ownership is not necessarily required to deliver space capabilities, whilst also emphasising the increasing interdependence between military, civil and commercial space sectors.

7.28. **Challenges to space launch.** The UK reliance on allies and partners to provide launch capabilities could raise potential issues of assurance, security and responsiveness. To mitigate this challenge, the UK is examining the potential of establishing a spaceport, as well as opportunities for commercial spaceflight and small-satellite launch activities.¹¹³ This could have the added benefit of taking advantage of the emergence of small satellites, which have reduced the cost of space capabilities. It may also offer a sovereign capability, through the timely deployment and replenishment of satellites from the UK, thereby increasing responsiveness to emerging operational requirements.

Key points

- The fundamental attributes of space power are: perspective, access, persistence and versatility.
- The four roles of space power are: space situational awareness; space control; space support to operations and space service support.
- The four roles of space power provide a basis for understanding the enabling and; operating characteristics of the environment.
- Space situational awareness underpins all other space roles, as it provides an understanding of the space operating environment.
- Space control involves affecting adversary space capabilities as well as assuring our own freedom of access to space.
- Space support to operations enables and enhances UK military capabilities, providing critical support to the combat effectiveness of the joint force.
- Space service support consists of operations that launch space assets and maintain and sustain them.

113 The UK seeks to enable new commercial markets to launch small-satellites and offer sub-orbital flights from the UK with the aim for the first commercial launch being in 2020. This may present the Ministry of Defence with an opportunity to deliver substantive military services and capabilities.



The employment of space power

Chapter 8 considers how we apply space power within a joint, multinational and inter-agency environment as part of a full spectrum approach. It also provides an overview of how we coordinate military space capabilities at the national and multinational level.

- Section 1 – Space contribution to joint action
and the full spectrum approach 111
- Section 2 – Coordinating UK space power 112
- Section 3 – Space operations 116

//

...the **utility of air and space power** in helping the Nation to meet its 21st Century defence and security challenges **is very well recognised and understood.**

//

Air Chief Marshal Sir Stephen Hillier,
Chief of the Air Staff

Chapter 8 – The employment of space power

Section 1 – Space contribution to joint action and the full spectrum approach

Joint action

8.1. The exploitation of the attributes and roles of space power provides a significant contribution to the successful employment of joint action. Freedom of action and the ability to directly influence adversaries is enabled by **space control** capabilities; understanding of space and other environments is underpinned by **space situational awareness**; operational effectiveness across all domains is enhanced by **space support to operations** and access to space and satellite operations is enabled by **space service support**.¹¹⁴

8.2. Joint military operations without space would mean no effective long-range, assured secure communications, severing our command and control links with deployed forces. We would not be able to plan effectively without accurate weather forecasting or operate many of our unmanned systems. Without accurate positioning, navigation and timing (PNT) information, all-weather, precision-strike capabilities would be severely degraded and a whole host of military applications would be severely affected. We would not be able to effectively track our forces, or monitor supplies, adversely affecting our logistics chain. The denial of space-based intelligence, surveillance and reconnaissance (ISR) would severely impact our ability to understand, while the ability to provide early warning of ballistic missile launches, or to accurately track and monitor missiles in flight, would be severely degraded.

The full spectrum approach

8.3. A full spectrum approach aims to use all instruments of national power in a coordinated manner to achieve political and strategic objectives.¹¹⁵ The coordination and synchronisation of these various levers of power reduces duplication of effort, creates synergies and leads to more effective use of resources. The appointments, requirements and elements of UK space power are spread across multiple agencies

¹¹⁴ See Chapter 7 for more details.

¹¹⁵ Diplomatic, military and economic instruments, all underpinned by information.

and government departments. It also has a significant input into the economic instrument of national power, serving as a testament to the role of space in a full spectrum approach.

8.4. The full spectrum approach can also be used to deter malicious space control activities, if the adversary understood that there was a plausible chance of attribution from another lever of power. Forcible military options will not always be available or appropriate to deal with low-level interference or harassment operations against UK space capabilities. Therefore, as part of efforts to protect UK space capabilities, the other instruments of national power, such as economic or diplomatic measures can be used, to deter potential adversaries from contesting national freedom of action in space. Within the military instrument of national power, the risk of provoking a forcible response from the maritime, land or air domains could be used to deter by convincing an adversary that they could suffer costs that would outweigh any benefits gained by disrupting, degrading, denying or destroying UK space capability.

Section 2 – Coordinating UK space power

UK civil coordination



8.5. The UK Space Agency helps to bring together UK civil and commercial space programmes and interests. It is an executive agency of the Department for Business, Energy and Industrial Strategy and is responsible for all strategic decisions on UK civil space programmes.¹¹⁶ It supports UK space industry initiatives and licences the launch and operation of all UK satellites, both military and non-military and has regulatory responsibilities under the 1986 Outer Space Act. It promotes cooperation through participation and contribution to the European Space Programme, and other European initiatives. The agency coordinates closely with a host of government departments and other space agencies around the world.¹¹⁷ Given the dual use of space assets and the importance of space, the UK Ministry of Defence (MOD) works very closely with the UK Space Agency.

¹¹⁶ The UK Space Agency is the UK Government lead for the *National Space Security Policy*.

¹¹⁷ For more detail, see the UK *National Space Policy*, page 5.

UK military coordination

8.6. From a military perspective, the Royal Air Force (RAF) is recognised as the most significant contributor to space operations, since it retains most of the UK's military space expertise and manages key UK space capabilities. The facility at RAF Fylingdales and the UK Space Operations Centre (UK SpOC) at RAF High Wycombe deliver a range of space services and missions to the MOD and broader government stakeholders, through the roles of space control, space situational awareness and space support to operations.

8.7. The UK SpOC serves as the operational focal point for most UK military space operations. It provides warning of overflight times of potentially hostile satellites, referred to as the Satellite Warning Service; collision warning between satellites and/or space debris; monitors treaty verification and compliance; establishes attribution of activities in space; provides missile and space-object re-entry warning; and delivers advice on space-related matters for military and civil contingency requirements. It is the military focal point for space weather forecasts and subsequent impacts to operations, and assesses Global Positioning System (GPS) accuracy predictions. Although the SpOC does not maintain a full space operating picture, it can assist a space representative within a headquarters or force element by building an understanding of how the events within the space environment may affect their operations.

8.8. Joint Forces Command (JFC) plays a central role in the coordination and delivery of UK space capabilities, particularly through the role of space support to operations, as it is the focus for ISR, satellite communications (SATCOM) and PNT capabilities. It coordinates UK ISR collect capabilities and requests ISR support from United States (US) space components. JFC also manages the Skynet SATCOM programme; SATCOM command and control is provided by the Permanent Joint Headquarters Global Operations and Security Control Centre. JFC liaises with the United States (US) on PNT issues and through Information Systems and Services (ISS) at MOD Corsham, which manages all UK orbital filings, including commercial entities.



Multinational coordination

8.9. Both the UK SpOC and JFC have close multinational links and are able to request support from the US and other allied space commands. They have a particularly close working relationship with the US Joint Space Operations Centre (JSpOC) and are able to source information derived from US space capabilities, to support UK military operations. Specific UK space support requirements are submitted to the US and are prioritised in accordance with bilateral agreements.

8.10. The UK has a mutually-beneficial relationship with the US, through the sharing of space capabilities. The facility at RAF Fylingdales is a joint enterprise between the UK and the US and is a key component of US space capability, as it contributes to the US Space Surveillance Network. The primary mission of RAF Fylingdales is missile warning and direct support to US Ballistic Missile Defence. The secondary mission of the facility is to support the role of space situational awareness. The US JSpOC uses data from the Space Surveillance Network to produce a space track catalogue, which is a continuously updated register of objects in space.



The solid state phased array radar at RAF Fylingdales contributes to UK and United States ballistic missile warning capability

8.11. The MOD has core links with the multinational Combined Space Operations (CSpO) initiative, which improves cooperation amongst the Five Eyes community, and others.¹¹⁸ The initiative seeks to empower partner nations to optimise resources, deepen coordination, strengthen deterrence, enhance mission assurance and increase the resilience of space capabilities. To help facilitate this, it conducts regular operations; capabilities and architecture; and policy and legal working groups, with the aim of enhancing collaboration between the member states.

8.12. The UK plays an active role in European space initiatives, which help to supplement UK space services. An example of this is the Copernicus Programme, a European Space Agency (ESA) Earth observation programme, which provides information to improve the management of the environment, understand and mitigate the effects of climate change and enhance civil security. The European Union (EU) Satellite Centre is a conduit for products and services resulting from the exploitation of member state space assets and the EU Space Surveillance and Tracking initiative is a civil enterprise, made up of a consortium of member states.¹¹⁹ The UK Space Agency is the UK lead in support of this partnership and the MOD provides support through the provision of UK SpOC analysis and service delivery functions.¹²⁰



North West England taken from the Sentinel-2A satellite, as part of the European Copernicus Programme

© ESA

118 Expanded to also include France and Germany with the potential for new partners in future.

119 France, Germany, Italy, Spain and the UK.

120 The UK uses existing civilian space capabilities to contribute to this initiative.

8.13. Although collaboration provides opportunities, such as affordable access to shared space capabilities, there are challenges with regard to classification and data-sharing. There are also potential risks in terms of the security, sovereignty and assurance of UK space services, so the maintenance of multinational relationships, through a collaborative approach, helps to assure UK access to such services.

Section 3 – Space operations

8.14. As part of the collaborative approach, and to ensure the maintenance of space expertise, influence and credibility, the UK embeds a number of military staff in multinational space operations centres. This allows us to represent UK interests, as well as coordinate and service UK space requirements, reaching back to the UK SpOC when required.

8.15. For US-led operations, the Space Coordinating Authority (SCA) is responsible for the coordination, planning and execution of space capabilities in support of military operations, on behalf of the joint force commander. The SCA is usually embedded in the Combined Air and Space Operations Centre.¹²¹ However, the authority for employment of the capabilities remains with the US JSpOC.



The US Joint Space Operations Center (JSpOC)

.....
121 See US Joint Publication 3-14, *Space Operations* and Allied Joint Publication (AJP)-3.3(B), *Allied Joint Doctrine for Air and Space Operations*, for more information.

Space planning considerations

8.16. Space-based services may be transparent or invisible to the end user, but they pervade almost every aspect of joint and combined operations. The space domain should therefore be considered as routinely as the other operating domains, and must be included in military planning processes and when developing joint campaign objectives or courses of action. Similarly, the potential for other domains to support space operations should be considered and, where necessary, integrated.

8.17. The unique characteristics of space and the difficulty in gaining access to it present unique planning considerations. There are numerous resource, logistical and legal considerations that must be included in the planning process to ensure mission success. Space planners must also understand the operational considerations for employing space capabilities and the threats that come with their use. Space dependencies and therefore potential vulnerabilities must be captured in the planning process to enable mitigation and contingency planning. Contingency plans will need to consider alternative options if space enablers are not available, due to denied or degraded performance, through factors such as space weather.

8.18. Although the effects may be unavoidable, some events can be predicted; forecasting and advice on the consequences of space weather can minimise the disruption to operations, through the implementation of contingency plans. Understanding solar events and their effects also enables similar-looking events to be determined as either naturally-occurring or caused by human activities. The UK SpOC is the MOD-facing organisation that relays space weather warnings and is the go-to organisation for this information, both as a source and for feedback on the effects to operational output.

8.19. ISR satellites can be used for a large range of tasks, so may not be able to accommodate tactical short-notice re-tasking. Military planners need to understand that it can be difficult to generate spare capacity within operationally useful timescales, either to meet surges in demand or to replace a satellite that may have been denied by enemy action, a natural hazard or technical failure. Unlike the flexibility offered by aircraft, manoeuvring satellites to cover gaps in desired coverage is inherently difficult. Even if a satellite's orbit can be adjusted, the change in orbit is often not significant in the short term, although in the longer term, it can achieve manoeuvre objective. Any requirement to manoeuvre and change satellite orbit therefore requires forethought in the planning process.

8.20. Although UK military satellites can be used to support tactical operations, they are generally strategic in nature and are employed globally to support multiple users simultaneously. This means they are unlikely to be allocated under the direct control

of an operational commander in a regional theatre. However, commanders and staff must still understand space capabilities and the potential threats posed to them so they can identify, bid for and monitor the delivery of the services they need.

Key points

- The exploitation of the attributes and roles of space power provides a significant contribution to the successful employment of joint action.
- The UK Space Agency helps to bring together UK civil and commercial space programmes and interests, and works closely with the UK Ministry of Defence.
- Both the Royal Air Force and Joint Forces Command have close multinational links and are able to request support from the United States and other allied space commands.
- Although collaboration provides opportunities, such as affordable access international space capabilities, there are challenges with regard to classification and data-sharing.
- As part of the collaborative approach, and to maintain space expertise, the UK embeds a number of military staff in multinational space operations centres.
- Satellite services may be transparent or invisible to the end user, but they pervade almost every aspect of joint and combined operations.
- The space environment should be considered as routinely as the other operating environments, and must be included in military planning processes.

Lexicon

Part 1 – Acronyms and abbreviations

A2AD	anti-access and area denial
AJP	Allied joint publication
ALI	air land integration
AP	Air publication
ATP	Allied tactical publication
C4I	command, control, communications, computers and intelligence
CAOC	Combined Air Operations Centre
CAS	close air support
CASOC	Combined Air and Space Operations Centre
CCA	close combat attack
CFACC	combined forces air component commander
DCA	defensive counter air
DCDC	Development, Concepts and Doctrine Centre
DFID	Department for International Development
DSC	defensive space control
EMS	electromagnetic spectrum
ESA	European Space Agency
FSA	full spectrum approach
GNSS	Global Navigation Space System
GPS	Global Positioning System
HAPS	high altitude pseudo satellite
ISR	intelligence, surveillance and reconnaissance
JDP	joint doctrine publication
JFAC	Joint Force Air Component
JSP	joint Services publication
JTAC	joint terminal air controller
JWP	joint warfare publication

LOAC	Law of Armed Conflict
MOD	Ministry of Defence
NATO	North Atlantic Treaty Organization
OCA	offensive counter air
OSC	offensive space control
PED	processing, exploitation and dissemination
PNT	positioning, navigation and timing
QRA	quick reaction alert
RAF	Royal Air Force
RPA	remotely piloted aircraft
SAM	surface-to-air missile
SATCOM	satellite communications
SBIRS	space-based infrared system
SCAR	strike coordination and reconnaissance
NSS/SDSR 2015	National Security Strategy and Strategic Defence and Security Review 2015
SpOC	Space Operations Centre
SSA	space situational awareness
UN	United Nations
US	United States
USAF	United States Air Force

Part 2 – Terms and definitions

This section lists the endorsed terms and definitions used in this publication which may be helpful to the reader.

air power

Using air capabilities to influence the behaviour of actors and the course of events. (JDP 0-30)

air logistic support

Those tasks conducted to deploy, sustain, distribute and recover personnel, equipment and supplies. It uses both inter and intra-theatre airlift. (Fighting Instructions Book of Reference (digital) 4487 Volume 2.1, *Strike Warfare*)

command

The authority vested in an individual of the armed forces for the direction, coordination, and control of military forces. (NATO*Term*)

control

The authority exercise by a commander over part of the activities of subordinate organizations, or other organizations not normally under his command, that encompasses the responsibility for implementing orders or directives. (NATO*Term*)

Defence Engagement

The means by which we use our Defence assets and activities, short of combat operations, to achieve influence. (JDP 04, 2nd Edition)

intelligence

The product resulting from the directed collection and processing of information regarding the environment and the capabilities and intentions of actors, in order to identify threats and offer opportunities for exploitation by decision-makers. (NATO*Term*)

intelligence, surveillance and reconnaissance

Activities that synchronises and integrates the planning and operation of collection capabilities, including the processing and dissemination of the resulting product. (JDP 2-00, 3rd Edition)

interoperability

The ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives. (NATO*Term*)

joint

Adjective used to describe activities, operations and organizations in which elements of at least two services participate. (NATO*Term*)

joint action

The deliberate use and orchestration of military capabilities and activities to create specific physical and/or psychological effects to influence a range of actors, including allies, civilian partners, regional and global audiences, as well as any adversary. (JDP 3-00, 3rd Edition)

joint force

A force composed of significant elements of two or more Services operating under a single commander authorised to exercise operational command or control. (JDP 01)

multinational

Adjective used to describe activities, operations and organisations, in which forces or agencies of more than one nation participate. (NATO*Term*)

space power

Exerting influence in, from, or through space. (JDP 0-30)

sustainability

The ability of a force to maintain the necessary level of combat power for the duration required to achieve its objectives. (NATO*Term*)


understanding

The perception and interpretation of a particular situation in order to provide the context, insight and foresight required for effective decision-making. (JDP 04, 2nd Edition)



Designed by the Development, Concepts and Doctrine Centre
Crown copyright 12/17
Published by the Ministry of Defence
This publication is also available at www.gov.uk/mod/dcdc

Corporate member of
Plain English Campaign
Committed to clearer
communication

235 

The logo for the Plain English Campaign, featuring a stylized quill pen.