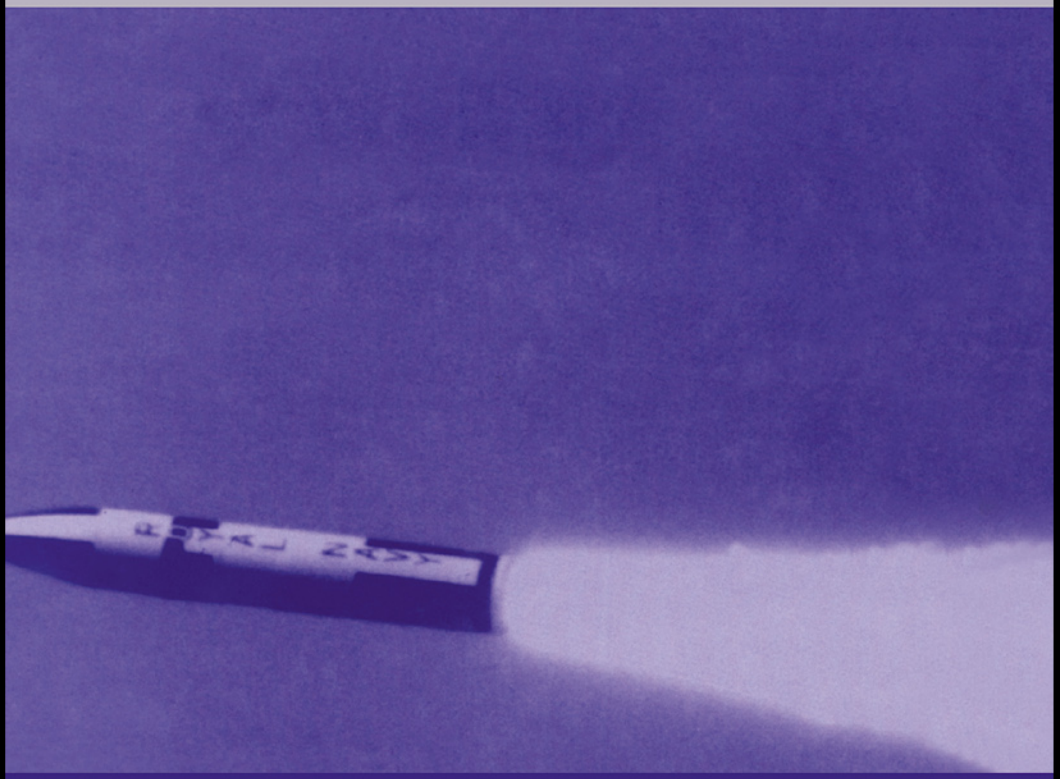
BRITAIN AND BALLISTIC MISSILE DEFENCE

1942–2002



Jeremy Stocker

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JEREMY STOCKER

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To my Father, Group Captain John Stocker RAF,

whose career in air defence spanned most of the period considered in this book

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Series Editor's Preface

An important function of this Series is to offer analyses of episodes or themes in strategic history that have been thus far neglected. The subject of Jeremy Stocker's study of *Britain and Ballistic Missile Defence, 1942–2002,* falls four-square in the 'neglected' category. On 8 September, 1944, Britain was the first victim in history to suffer assault by a ballistic missile (Germany's V-2). From that time to the present day, the country has a continuous, if often all but inactive, record of concern about, and some involvement in, ballistic missile defence (BMD). Despite that lengthy experience, prior to the publication of Dr. Stocker's book there was no extant comprehensive examination of Britain and BMD. The author claims, without risk of contradiction, to provide the first study that traces the full history of how Britain responded to the challenge posed by the menace of ballistic missile attack over a period of no less than sixty years.

It is somewhat surprising that this should be such an innovative work. After all, since the late 1960s BMD has been by far the single most controversial topic in Western defence strategy, and arms control. Indeed, as Dr. Stocker makes abundantly clear, although his subject is 'Britain and BMD', the main issue almost always has been Britain's attitude towards the latest shift in American policy on the matter. Inhabiting a small and crowded island, the British have long elected to adopt a principally political approach to their national security in the nuclear age. In the context of a large, then very large, Soviet nuclear-missile threat, even a *fairly* competent BMD architecture did not have much to offer Britain by way of reliable physical protection. That strategic judgment is offered in addition, of course, to the all too obvious issues of military-technical feasibility and affordability. In British, indeed in NATO-European, eyes, the first line of security against the nuclear-missile menace was diplomacy. For reasons of political culture, strategic conviction, and expediency, Britain—and Europe, more generally—has always looked to arms control diplomacy to provide, or at least help shape, a context that would blunt the missile danger. Dr. Stocker makes the point with an admirable directness. He characterises the ABM Treaty of 1972 as 'the defining event in the UK's responses to both US and Soviet ABMs (p.6)'. Literally for thirty years the Treaty served as the Hindenburg Line against the periodic flurry of renewed US interest in moving BMD from research and development into a more active phase. In the Cold War years, at least, the Treaty was portrayed as the essential protector against a more heated strategic arms race (defence-offence, or offence-defence).

BMD is a deeply technical subject, as the author's narrative makes very plain. However, if anything it is even more deeply political than technical. The ABM Treaty was regarded, by its friends and foes alike, as the jewel in the crown of arms control. It was the most substantial achievement of arms control policy and diplomacy in the Cold War. A rigorous critic of the Treaty, Dr. Donald G. Brennan, observed ruefully at the time that the Treaty 'did the wrong thing well'. The Treaty denied the superpower signatories the right to deploy a missile defence of their national territory. The theology of nuclear era strategic theory was central to the argument. Allegedly, it was beneficial

for strategic stability—the holy grail of the period—for each side to enjoy unrestricted military access to the other's society. More theology asserted that defensive systems must spur the deployment of more, or more sophisticated, offensive weapons: so BMD inexorably would fuel a defence-offence spiral of arms competition. For a quarter century, strategic theorists and defence analysts engaged repeatedly in the kind of 'expert' strategic debate that tends to give such debate a bad name. Theories were advanced as facts—on both sides, let it be said—and the only certainty about the subject was that BMD was a topic that would be certain to come round again in the next major review of US nation-al security policy. Although the issues could hardly be more technical, the on-off-on 'debate' was always dominated by political attitudes. BMD became an iconic subject, for all parties to the long running dispute.

From 1972 until its formal demise in June 2002, the existence of the ABM Treaty, and the vociferous arguments of its large body of, principally liberal, American admirers, allowed London to conceal its distaste for BMD. Today, however, the absence of a strategic arms race, an apparently relaxed Russian attitude towards American BMD, the demise of the Treaty, and the transformation of the threat context, makes it close to a certainty that BMD's hour is arriving at last. To understand the choices that Britain will face, and the beliefs and assumptions it will bring to the subject, it is essential to know where the country has been. Dr. Stocker's book is an outstanding contribution to the shedding of light on an unduly foggy topic. As often as not, BMD has been debated in technical, or pseudo-technical terms (could as-yet unbuilt US defences handle as-yet undemonstrated Russian countermeasures), when both sides really regarded the matter as being primarily one of political symbolism. To oppose BMD was to oppose the arms race, to 'believe in' arms control, and—ergo—to stand for peace!

Good strategic history cannot provide a truly robust defence against the repetition of folly, but it can only help. We are very pleased to add Dr Stocker's careful study to the Series.

Colin S.Gray, Series Co-Editor.

Acknowledgements

This book is a revised version of my PhD thesis, submitted to the Centre for Security Studies, University of Hull. I must therefore thank my supervisor, mentor and friend, Dr Eric Grove, whose light touch provided just the right amount of guidance and direction. I should also thank my examiners, Professor Martin Edmonds and Dr Tom Kane, whose rigorous yet sympathetic grilling caused me to question, justify and sometimes revise the judgements I have made. I am also in the debt of Dr Robin Ranger, through whom I first became interested in missile defence.

Much of my original research was done at the Public Record Office in Kew. The members of staff of that organization are a fine example of how a public service can and should operate. They made every visit to the PRO a positive pleasure.

I should also like to thank the numerous individuals, serving and retired, uniformed and civilian, who provided me with many valuable insights. Their assistance helped me to make sense of the bare documentary record, and gave me a closer understanding of how policy continues to evolve. Any errors of fact or judgement are, of course, solely mine.

For permission to reproduce photographs, diagrams and tables, I am grateful to the Public Record Office, the Imperial War Museum, the Ministry of Defence and the House of Commons.

My last and greatest thanks must be to my wife Judith, for everything.

Abbreviations

AA	Anti-Aircraft
ABL	Airborne Laser
ABM	Anti-Ballistic Missile
ABT	Air-Breathing Threat
ACAS	Assistant Chief of Air Staff
ACCS	Air Command and Control System (NATO)
ACDRU	Arms Control and Disarmament Research Unit
ADGB	Air Defence of Great Britain
ADOC	Air Defence Operations Centre
AEW	Airborne Early Warning
AGARD	Advisory Group for Aerospace Research and Development (NATO)
AHB	Air Historical Branch
AHB Vol. VI	Air Ministry Air Historical Branch, *RAF Narrative Air Defence of Great Britain, Vol. VI: The Flying Bomb and Rocket Campaign 1944–1945*
AIT	Atmospheric (or Advanced) Interceptor Technology
AMES	Air Ministry Experimental Station
AOC	Air Officer Commanding
AOC-in-C	Air Officer Commanding-in-Chief
ASR	Air Staff Requirement
AST	Air Staff Target
ATBM	Anti-Tactical Ballistic Missile
AWRE	Atomic Weapons Research Establishment
BMD	Ballistic Missile Defence
BMDO	Ballistic Missile Defense Organization (US)
BMEWS	Ballistic Missile Early Warning System
BPI	Boost Phase Intercept
CAS	Chief of the Air Staff
CDISS	Centre for Defence and International Security Studies
CEC	Cooperative Engagement Capability
CEP	Circular Error Probable
CG	Command-Guidance

CH	Chain Home
C-in-C	Commander-in-Chief
CMAS	Cheyenne Mountain Air Station
CNAD	Conference of National Armaments Directors (NATO)
CoS	Chiefs of Staff
CRDF	Cathode-Ray Direction Finding
CRS Report	Paul E.Gallis *et al., The Strategic Defense Initiative and United States Alliance Strategy* (Washington, DC: Congressional Research Service, 1 February 1985)
CSA	Chief Scientific Advisor
CW	Continuous Wave
DCAS	Deputy Chief of the Air Staff
DDOR5	Deputy Director Operational Requirements
DEC(TA)	Directorate for Theatre Airspace
DERA	Defence Evaluation and Research Agency
DEW	Directed Energy Weapon
DGP	Defence Group on Proliferation (NATO)
DRPC	Defence Research Policy Committee
DSP	Defense Support Program (US)
EAD	Extended Air Defence
EDI	European Defence Initiative
ERINT	Extended Range Interceptor
FCO	Foreign and Commonwealth Office
FIS	Fundamental Issues Study
FIS	N.Brown, *The Fundamental Issues Study with the PreFeasibility Programme* (Oxford: Manfield College, 1998)
GAO	General Accounting Office
GAO Report	General Accounting Office, *Strategic Defense Initiative Program: Extent of Foreign Participation* (Washington, DC: General Accounting Office, February 1990)
GBR	Ground-Based Radar
GMDS	Ground-Based Midcourse Defense Segement
GPALS	Global Protection Against Limited Strikes (US)
HE	High Explosive
HF	High Frequency
HOE	Homing Overlay Experiment
ICBM	Inter-Continental Ballistic Missile

INF	Intermediate Nuclear Forces
IR	Infra-Red
IRBM	Intermediate Range Ballistic Missile
ISS/IISS	(International) Institute for Strategic Studies
JIC	Joint Intelligence Committee
JSWS	D.Lennox *(ed.), Jane's Strategic Weapons Systems*, Issue 34 (Coulsdon: Jane's, 2001)
JTWC	Joint Technical Warfare Committee
KEW	Kinetic Energy Weapon
KKV	Kinetic Kill Vehicle
km	Kilometres
kph	Kilometres Per Hour
kt	Kiloton
LDS	N.Brown, *Ballistic Missile Defence: A British Perspective*, London Defence Studies No. 27 (London: Centre for Defence Studies, 1995)
LEAP	Lightweight Exo-Atmospheric Projectile
MAD	Mutual Assured Destruction
MDA	Missile Defense Agency (US)
MEADS	Medium Extended Air Defense System (US/Ger/It)
MESAR	Multifunction Electronically Scanned Adaptive Radar
MIDAS	Missile Defense Alert System (US)
MIRV	Multiple Independently Targeted Re-entry Vehicle
MoD	Ministry of Defence
MOR	Military Operational Requirement
MoU	Memorandum of Understanding
MRBM	Medium Range Ballistic Missile
MSAM	Medium Surface-to-Air Missile
MT	Megaton
MTCR	Missile Technology Control Regime
NADC	NATO Air Defence Committee
NADGE	NATO Air Defence Ground Environment
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological, Chemical
NC3A	NATO Consultation, Command and Control Agency
NIAG	National Industrial Advisory Group (NATO)
nm	Nautical Miles

NMD	National Missile Defence
NORAD	North American Air Defense (Canada/US)
NPG	Nuclear Planning Group (NATO)
NPT	Non-Proliferation Treaty
OPCON	Operational Control
OTH	Over The Horizon
PAAMS	Principal Anti-Air Missile System (Fr/It/UK)
PAC	Penetration Aid Carrier (UK) or Patriot Advanced Capability (US)
PFP	Pre-Feasibility Programme
PFS	Pre-Feasibility Study
PRO	Public Record Office (now part of the National Archives)
PSO	Peace Support Operation
PUS	Permanent Under-Secretary
R&D	Research and Development
RAE	Royal Aircraft Establishment (Farnborough)
RAF	Royal Air Force
RCM	Radio Counter-Measures
RCS	Radar Cross-Section
RF	Radio Frequency
RO	Research Objective
RRE	Royal Radar Establishment (Malvern)
RUSI	Royal United Services Institute
RV	Re-entry Vehicle
SADTC	SHAPE Air Defence Technical Centre (NATO)
SAGW	Surface-to-Air Guided Weapon
SALT	Strategic Arms Limitations Talks
SAM	Surface-to-Air Missile
SAMP/T	Sol-Air Moyenne Portee / Terre (Fr)
SBIRS	Space-Based Infra-Red System
SBL	Space-Based Laser
SCORE	Scientific Corporation Research Exchange Programme
SDI	Strategic Defense Initiative (US)
SDIO	Strategic Defense Initiative Office
SDIPO	Strategic Defence Initiative Participation Office (UK)
SDR	Strategic Defence Review (UK)

SHAEF	Supreme Headquarters Allied Expeditionary Force
SHAPE	Supreme Headquarters Allied Powers Europe (NATO)
SLBM	Submarine Launched Ballistic Missile
SofS	Secretary of State
SRBM	Short Range Ballistic Missile
SSPAR	Solid State Phased Array Radar
TA	Technical Area
TACON	Tactical Control
TBM	Theatre Ballistic Missile
TBMD	Theatre Ballistic Missile Defence
TEL	Transporter-Erector-Launcher
THAAD	Theater High Altitude Air Defense (US Army)
TMD	Theatre Missile Defence
TRRAP	Technology, Readiness and Risk Assessment Programme
TRRAP Report	Director of Strategic Technologies, MoD, *The Technology Readiness and Risk Assessment Programme: A Summary Report*, February 2002
WEU	Western European Union
WMD	Weapons of Mass Destruction

1
Introduction

The UK was the first country ever to come under sustained ballistic missile attack, in 1944–45. Defence against these weapons has been a persistent topic of policy and technical investigation for the UK ever since. It has been a contentious political issue on three main occasions, each of them in response to a planned US deployment of defences. The UK's own efforts to develop missile defences have largely gone unnoticed outside a small military and technical community. In fact, the greatest amount of work done in the UK in the field has actually been to overcome Soviet missile defences, rather than to produce them for the UK. At the end of the twentieth century, the UK was considering how to respond to an imminent US deployment of missile defences, and whether to acquire its own.

Because of its very high speed, range and altitude, defence against the ballistic missile in flight has always presented formidable technical problems. Just as problematic have been the political and strategic issues surrounding missile defence, not least because of the association between ballistic missiles and nuclear weapons.

Many of these wider issues have lain at the heart of foreign policy and national strategy since the end of World War II. A condition of stable nuclear deterrence became the basic requirement for national survival for most of the Cold War, and ballistic missile defence (BMD) has been a major factor in that equation, both for those that had, or were developing, missile defences, and those that did not. Missile defences were themselves the subject of arms control and underpinned other, more wide-ranging, agreements. BMD has often been a significant factor in transatlantic relations and specifically in NATO alliance cohesion. It has also been an item in relations between the West and Moscow, especially since the end of the Cold War.

Only four countries have had indigenous ballistic missile defence programmes: the United States, the Soviet Union, the UK and Israel, the latter with considerable US assistance. In each case, BMD development has followed a few years after a state's nuclear weapons programme, though this seems more coincidental than a direct consequence. US research into missile defence began in February 1946 as a result of a study of the V-2 campaign, and has, in one form or another, continued to the present day.[1] The Soviet Union is known to have begun considering ABM development as early as 1948, but the decision to develop a defence system was probably not taken until after Stalin's death in 1953.[2] Israeli development of its Arrow system began in 1986 with the signing of a Memorandum of Understanding (MoU) with the United States.[3] Of these three, only Russia and Israel currently have BMD systems deployed, though the operational status of the Russian system around Moscow is uncertain. The United States will deploy a range of BMD systems over the next decade.

When Britain was attacked by German V-2 rockets in 1944–45, its gun-based defence proposals were somewhat 'Heath Robinson', were never implemented, and ceased at the

end of the War. The UK did not resume work on missile defence until 1954 and unlike the other three states never came close to deploying an operational system.

Defence against ballistic missiles has, however, been a persistent issue for successive British Governments except, ironically, during the one period when development of an actual system was proceeding. More important by far than Britain's own hesitant attempts to develop defences, have been UK attitudes and responses to the other countries' missile defences.

At the start of the twenty-first century, BMD was once again a subject of both technical investigation and policy debate. The UK was moving cautiously towards the procurement of some form of missile defence, while at the same time a major shift in official thinking on the subject saw many long-held axioms being overturned, a British Government, for the first time, viewing an imminent US deployment of missile defences with a degree of equanimity. Outside government circles, however, missile defence has lost none of its controversy.

A ballistic missile is a form of rocket that can be used to deliver a variety of payloads via the upper atmosphere and space back to earth, at very high speeds and over very long ranges. It is closely related to spacelaunch vehicles which are used to deploy satellites into orbit—indeed the two are largely interchangeable. It is powered only for the early part of its travel, following a ballistic trajectory thereafter, somewhat like an artillery shell.[4] The missile is propelled upwards by one or more boosters burning liquid or solid fuel. It includes a guidance and control system, a warhead, and protection against the extreme environments experienced during ascent and descent through the atmosphere. Some missiles carry one or more separating re-entry vehicles (RVs), but simpler systems like the ubiquitous 'Scud' do not, the missile returning to earth largely intact.

Ballistic missiles have, since the mid-1950s, been closely associated with nuclear warheads, but they can be used to deliver other Weapons of Mass Destruction (WMDs)—biological, chemical or radiological—or conventional high explosives.

The technicalities of intercepting and destroying a ballistic missile are related directly to the three phases of its trajectory. As it climbs up out of the earth's atmosphere with the boosters still attached and burning, the missile is large, hot and relatively slow, but accelerating. It is easily detected by radar and particularly by infra-red sensors. Interception during the boost phase, however, is more problematic, as a defensive weapon needs to be positioned within range and have a very fast speed of reaction, which is generally taken to require directed-energy weapons, such as lasers, rather than an aerodynamic missile.

Once the booster(s) have burnt out and separated, the remaining front end of the missile carrying one or more warheads follows a ballistic trajectory through the upper atmosphere and into near space. During this mid-course phase it is much smaller and cooler than hitherto. Multiple warheads and decoys, where present, will separate. Infra-red detection becomes much more difficult, though radar tracking is still possible, made easier by the stable, predictable path that the missile follows. Interception in space requires a missile that can manoeuvre without the use of aerodynamic control surfaces.

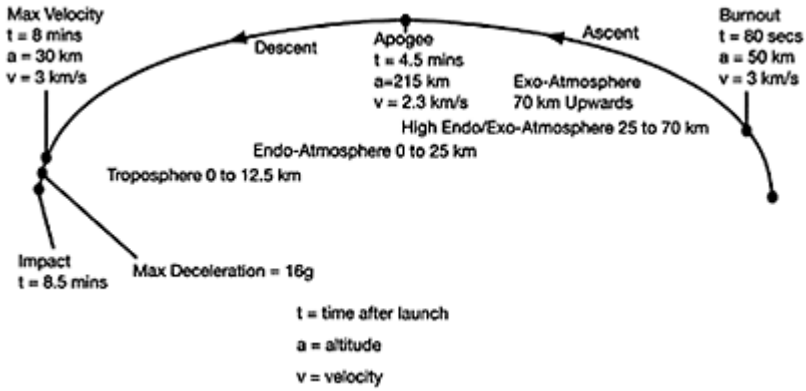
During the final terminal phase, the one or more RVs descend towards their intended target(s). The effect of re-entering the atmosphere will be to slow (or 'retard') the missile. All but the most sophisticated decoys, being lighter, will fall behind the warheads. Interception is now possible by a conventional aerodynamic missile, which may itself be

an adaptation of a weapon designed to intercept ‘air-breathing’ threats (ABT), such as manned aircraft and cruise missiles.

The range of a ballistic missile following an ‘optimum’ trajectory is directly proportional to speed, though missiles can be ‘depressed’ or ‘lofted’ with some range/payload penalty. On an optimum trajectory a missile’s apogee (maximum altitude) will be roughly 20 per cent of its range, thus a missile with a range of 1,000 km will climb to a maximum height of about 200 km. Because of the curvature of the earth, ascent and descent angles will be between about 35° and 43°, longer ranges inducing shallower angles. Even a relatively short-range ‘Scud’ will travel at speeds of up to 2 km per second, and an intermediate-range missile travelling 3,500 km will attain a speed of 5 km per second—about 11,000 miles per hour.

The appreciable atmosphere extends upwards to about 70 km. Even a relatively short-range missile will therefore climb beyond it, and longer-range systems spend the great majority of their time outside the atmosphere altogether. Interceptions within and beyond the atmosphere are known as endo- and exo-atmospheric, respectively.

Figure 1: Typical Ballistic Missile Trajectory



Source: DERA/WX9/6/173/1/3/2/2.0. *The UK Ballistic Missile Defence Pre-Feasibility Programme Report*, June 1998, p. 2; © Crown Copyright/MOD. Reproduced with the permission of the Controller of Her Majesty’s Stationery Office.

Figure 2: Summary of Ballistic Missile Interception Terminology

System Type	*Operating Region*	*Also known as*
Endo-atmospheric	up to 25 km	Point Defence
		Lower Tier
		Lower Layer
		EAD (if system has an ABT Capability)

High Endo/Exo-atmospheric	above 25 km	Area Defence
		Upper Tier
		Upper Layer
Exo-atmospheric	70 km upwards	Area Defence
		Upper Tier
		Area Defence
Ascent Phase Kill	pre apogee	BPI (boost phase only)
		PBI (post boost phase only)

Source: DERA PFP Report, p.3; © Crown Copyright/MOD. Reproduced with the permission of the Controller of Her Majesty's Stationery Office.

A successful interception requires two fundamental problems to be solved—discrimination (finding the warhead) and lethality (destroying it). This is true of any target and any weapon system, but is particularly challenging for BMD in view of the very high speeds, ranges and altitudes involved.

Active defence entails the physical interception and neutralisation of a ballistic missile after it has been launched. It is, however, only one of a number of counters to this type of threat.

The first is a diplomatic response, to prevent missiles and their associated warheads being secured by potential enemies. Export controls and arms control agreements are examples of non-proliferation. The second is deterrence, seeking to dissuade a state from employing the weapons in its possession, and is particularly associated with nuclear-armed missiles. A third approach is counter-force, the pre-emptive destruction of missiles on the ground prior to launch.[5] And finally, if all these and active defence are unsuccessful, passive defence (sometimes known as civil defence) seeks to ameliorate the effects of the missile's warhead once it reaches its target. Passive defence measures include concealment, hardening and decontamination.[6]

Ballistic missiles can, broadly, be employed to meet two kinds of objective. Particularly (but not only) when carrying nuclear warheads, they may be used for direct, strategic effect. In this role they have largely, though not entirely, supplanted the manned bomber. They can also be used in a tactical role, against targets of military importance. This distinction is not absolute, however. Bombardment of a major port, for example, may have both strategic and tactical significance. But it remains a useful categorisation, and defence against ballistic missiles may therefore also be 'strategic' or 'tactical'. Only the former has, in general, generated much political interest and dispute, the latter being little more than a technical challenge subject to operational requirements, financial constraints and competing priorities. Until recently, the US Government classified missile defences into Theater Missile Defense (TMD) and National Missile Defense (NMD), though the former included defence of regional friends and allies (strategic) as well as forces deployed overseas (tactical).

Defence against ballistic missiles was, until the early 1970s, usually referred to as Anti-Ballistic Missile (ABM) defence. Since then, the term has tended to be replaced by Ballistic Missile Defence (BMD), though the two are essentially interchangeable.

The first operational ballistic missile was the German V-2. Most missiles today can trace their origins, directly or indirectly, back to that original, revolutionary weapon. The early Soviet missiles were developed straight from the V-2, and though US missile developments featured rather more original, indigenous work, the US programme was headed for many years by the V-2's chief designer, Wernher von Braun.[7]

Despite the Cold War association between ballistic missiles and nuclear warheads, all of the 5000–6,000 ballistic missiles actually fired in anger have carried high-explosive warheads (see Table 1).

Table 1: History of Ballistic Missile Use

Conflict	*Dates*	*Missile*	*User*
World War II	1944–45	V-2	Germany
Yom Kippur	1973	Scud & FROG	Egypt & Syria
Iran-Iraq	1984–88	Scud & FROG	Iran & Iraq
US–Libya	1986	Scud	Libya
Afghan Civil War	1988–91	Scud	Afghanistan
First Gulf War	1991	Al Hussain† & FROG	Iraq
Yemen Civil War	1994	Scud & SS-21	Yemen
Taiwan Crisis*	1995–96	M-9	China
Chechnya	1999	Scud & SS-21	Russia
Iraq	2001	Scud & Mushak	Iran
Second Gulf War	2003	Al Samoud	Iraq

* Demonstration firings for coercive effect
† An Iraqi-modified Scud
Complied by the author from various open sources

There is a very substantial body of secondary literature on the subject of ABM/BMD. Most, though not all of it, is American. Much of it deals with US missile defence, especially the 1980s Strategic Defense Initiative (SDI) and post-Cold War TMD and NMD.[8] Although several works have been published in the UK, especially among the Adelphi Papers monograph series from the International Institute for Strategic Studies (IISS) in London, many of them are by US authors and deal with US defences. Some of the literature does deal with European attitudes to US programmes, often a chapter or two in a more general work.[9] So-called theatre or tactical missile defences for Europe have their own literature.[10]

The only part of the UK BMD story extensively covered in published works is the World War II V-2 experience, on which there are plenty of books, a mix of official, scholarly and more popular volumes.[11] Other than the official histories, few deal with active defence plans in any detail, which can, however, be readily traced in files now held in the Public Record Office (PRO) in Kew. Though there is an extensive literature on postwar defence policy and particularly on its nuclear dimension,[12] BMD gets hardly a

mention. Such references as there are relate to US and, to a much lesser extent, Soviet ABMs.

The year 1972 marks a major watershed in Britain's BMD story, and not only because it represents the exact half-way point. Coincidentally, the 30-year point at which most, though not all, official documents are released into the public domain at the PRO falls in the same year as the signing of the Anti-Ballistic Missile (ABM) Treaty. Though Britain was not a signatory to the Treaty, it played an absolutely pivotal role in UK policy towards BMD, then and ever since. The ABM Treaty was the defining event in the UK's responses to both US and Soviet ABMs.

The period up to the signing of the Treaty is well covered by material now available at Kew, though some technical files have been retained beyond the 30-year point. Because of the ABM Treaty, the subject went very quiet for over a decade thereafter, apart from the Chevaline Polaris Improvement Programme designed to overcome the Moscow ABM system, and which had already been set in train by then anyway. It is unlikely, therefore, that many fresh revelations on UK policy towards missile defence will be forthcoming in the next decade. Indeed, one promising-looking file entitled 'Ballistic Missile Defence 1974–1978',[13] which it was possible to get released ahead of the 30-year point, contained no more than details of the routine five-yearly renewal of the BMEWS Agreement.

The British story on BMD picks up again in 1983 with President Ronald Reagan's seminal speech on missile defence. The absence of primary source material in the PRO is in part compensated for by the increasing number of public statements on the subject made in Parliament, the media and in speeches and journals. Evidence taken by the House of Commons Public Accounts, and later the Defence and Foreign Affairs Committees, provides a rich source of primary, albeit unclassified, material. The large body of contemporary secondary literature also indicates the terms of the policy debate at the time. I have been able to talk, often on a non-attributable basis, to several of the key individuals in both the policy and technical aspects of UK BMD throughout most of the period considered in this work.

This study is the first ever attempt to trace the full history of the UK's involvement with BMD. It uses a combined chronological and thematic structure. Each chapter deals with a distinct element of the story. There is, however, a general chronological progression within each chapter, and the chapters themselves fall into a natural chronological order. Some of these do, however, run in parallel for parts of their length. For example, British concerns about US and Soviet ABM developments ran largely concurrently, though the UK's response to Soviet ABMs outlasted its worries about the US ABM programme.

Despite the greatly changing technical and strategic contexts for missile defence over the last 60 years, many consistent issues are apparent. The concluding chapter seeks briefly to draw the most salient ones together.

NOTES

1. For the early history of US ABM work, see Donald Baucom, *The Origins of SDI 1944–1983* (Lawrence, KS: University Press of Kansas, 1992), Ch. 1.
2. Jennifer G.Mathers, *The Russian Nuclear Shield from Stalin to Yeltsin* (Basingstoke: Macmillan, 2000), pp. 3–4.

3. For several Israeli views on BMD, and details of the Arrow system, see Ariel Stav (ed.), *Ballistic Missiles: The Threat and The Response* (London: Brassey's, 1999).
4. The technical description which follows draws on Mark Hewish and Barbara Starr, 'Catching the Bullet: Theatre Missile Defense Faces Realities', *International Defense Review,* Vol. 27, June 1994, pp. 34–5, and Michael Rance, 'Ballistic Missile Defence—An Overview', *Journal of Defence Science,* Vol. 2, No. 1, January 1997, pp. 2–6.
5. See Tim Ripley, *Scud Hunting: Counter-force Operations against Theatre Ballistic Missiles,* Bailrigg Memorandum 18 (Lancaster: Centre for Defence and International Security Studies, 1996), for an examination of one such campaign.
6. For a fuller discussion of the relationship between the various non- and counter-proliferation elements, see J.Stocker, 'Ballistic Missile Defence', *International Security Review 1998* (London: Royal United Services Institute, December 1997).
7. For details of Soviet and American ballistic missiles, see Duncan Lennox (ed.), *Jane's Strategic Weapons Systems,* Issue 34 (Coulsdon: Jane's, 2001). (Henceforth cited as *JSWS.)*
8. Amongst the major works on pre-SDI ABM are Johan J.Holst and William Schneider (eds), *Why ABM?: Policy Issues in the Missile Defense Controversy* (New York: Pergamon Press, 1969); Abram Chayes and Jerome B.Weisner, *ABM: An Evaluation of the Decision to Deploy an Anti-Ballistic Missile System* (London: Macdonald, 1970); Benson D.Adams, *Ballistic Missile Defence* (New York: American Elsevier, 1971); and the more recent work by the BMDO Official Historian, Donald R.Baucom, *The Origins of SDI 1944–1983,* already cited.
9. Books that deal specifically with Europe and BMD include Ivo H.Daalder, *The SDI Challenge to Europe* (Cambridge, MA: Ballinger, 1987); Sanford Lakoff and Randy Willougby (eds), *Strategic Defense and the Western Alliance* (Lexington, MA: Lexington Books, 1987), and Hans Gunter Brauch (ed.), *Star Wars and European Defence* (Basingstoke: Macmillan, 1987).
10. Donald L.Hafner and John Roper (eds), *ATBMs and Western Security: Missile Defenses for Europe* (Cambridge, MA: Ballinger Publishing, 1988), and David Rubenson and James Bonomo, *NATO's Anti-Tactical Ballistic Missile Requirements and their Relationship to the Strategic Defense Initiative* (Santa Monica, CA: RAND Corporation, December 1987).
11. The official history of the V-2 campaign is contained in Basil Collier's one-volume *The Defence of the United Kingdom* (London: Imperial War Museum, 1957). A revised version of his account that deals specifically with the V-1 and V-2 is Basil Collier, *The Battle of the V-Weapons 1944–1945* (London: Hodder & Stoughton, 1964). The multivolume official history Air Ministry Air Historical Branch, *RAF Narrative Air Defence of Great Britain,* has as yet not been fully published. *Vol. VI: The Flying Bomb and Rocket Campaigns 1944–1945* is in the PRO (AIR 41/55). (Henceforth cited as *AHB Vol. VI.*) One of the better-known secondary works that retains its value is the controversial historian David Irving's *The Mare's Nest* (London: William Kimber, 1964). More recent works are Benjamin King and Timothy Kutta, *Impact: The History of Germany's V-Weapons in World War II* (Staplehurst: Spellmount, 1998), and Roy Irons, *Hitler's Terror Weapons: The Price of Vengeance* (London: HarperCollins, 2002).
12. Including Andrew J.Pierre, *Nuclear Politics: The British Experience with an Independent Strategic Force 1939–1970* (London: Oxford University Press, 1972), Lawrence Freedman, *Britain and Nuclear Weapons* (London: Macmillan, 1980), and Robert Paterson, *Britain's Strategic Nuclear Deterrent* (London: Frank Cass, 1997).
13. DEFE 13/995.

2
The Wartime V-2 Experience

THE V-2 PROGRAMME

The ballistic missile age began in earnest at 6.43 p.m. on 8 September 1944, when a German V-2 rocket landed in Staveley Road, Chiswick, in west London.[1] In fact, a rocket had landed in a Paris suburb earlier that day, but the Chiswick incident, in which 2 people were killed and 20 injured,[2] is generally acknowledged as the first operational use of a ballistic missile. Sixteen seconds later another V-2 landed harmlessly in Epping Forest.

The ensuing six-and-a-half month campaign remains, over half a century later, 'the leading example of the use of ballistic missiles in warfare'.[3] Most elements of subsequent ballistic missile developments, and counters to them, were present in 1944–45: an ambitious technological programme, uncertain but improving intelligence about the missiles, a strategic rather than purely tactical plan for their actual employment, efforts to locate and destroy them on the ground, development of a sophisticated (and generally successful) early warning network, and a mix of (less successful) passive and active defences. Missing from the V-2 campaign were only efforts to limit their proliferation by means of arms control, and to limit their use by deterrence. Of course, World War II as a whole stemmed in part from failures of both those approaches, though in a more general context.

Like many of the notable German weapons of World War II, development of the V-2 had begun in the early 1930s, before the Nazis came to power. Private research into rockets began in the 1920s and by 1932 the German Army was sufficiently interested to set up its own laboratory, one of whose earliest employees was Wernher von Braun.[4] The Army saw rockets as a form of artillery, one that was not proscribed by the Treaty of Versailles.[5]

The Reichswehr's rocket team, led by an artillery engineer Captain Dornberger, achieved its first success in 1934 when the *Aggregat* (prototype) -*2* (or A-2), was first launched. It was followed by a larger A-3 in 1936–37, by which time an operational version (A-4) had been designed.[6] Mass production of the still untested weapon was authorised by the Army itself in October 1939,[7] The project was not accorded a high priority, however, until more than a year later by which time it was clear that neither invasion nor conventional aerial bombardment would bring about Britain's defeat.[8] The first test launch took place at the Peenemunde research establishment on the Baltic coast on 13 June 1942. It was a failure, as was a second test in August. But on 3 October an A-4 prototype flew 118 miles along the coast and landed within 4,000 yards of its target.[9]

Though subsequent tests were not always as successful, Hitler himself authorised full-scale production in December 1942. However, a year later there were still no operational missiles in existence and it took a film-show of a launch fully to convince Hitler that development should continue.[10] The Luftwaffe was in parallel developing a pilotless