TO WHAT DEGREE DID THE RAF MAINTAIN V-FORCE OPERATIONAL EFFECTIVENESS IN THE 1960s?

Thesis

Submitted for the Degree of Doctor of Philosophy in War Studies Research

King's College, London

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2022

CONTENTS

ABSTRACT

This thesis considers the degree to which the RAF succeeded in maintaining V-Force operational effectiveness in the 1960s. Its broad objective is to enhance understanding of the V-Force role.

The open literature contains no evaluation of Medium Bomber Force (MBF) operational effectiveness, focusing instead on general descriptions of the V-Force, V-bomber types, the evolution of the British deterrent and the Anglo-American nuclear relationship. There has been no assessment of V-Force vulnerabilities, on the ground and in the air, efforts made to reduce these exposures and the V-Force potential to deliver retaliation.

Ballistic missiles have dominated strategic deterrence since the 1960s. Beyond the relatively brief hosting of American Thor missiles, however, British deterrence relied on a small fleet of subsonic bombers. This thesis is the first comprehensive account of this force, its war planning and operational capabilities.

The thesis draws on Bomber Command Operational Research Branch (ORB) studies, other documentary evidence and extensive contact with V-Force veterans. This overview of operational effectiveness is based on realistic assumptions, notably the likelihood of very short warning. V-Force retaliation had three main elements: war scramble survival, successful penetration and accurate weapons delivery. Surviving a low trajectory IRBM strike was the starting point. This required part of the force to be held, round-the-clock, at Cockpit Readiness (to the point of engine start), as provided for under “Alert Condition 1” - introduced in 1961. This was the ultimate Ground Alert posture and the only option which would have allowed at least some bombers to escape and retaliate.

The V-Force’s primary role was deterrence – war prevention rather than war-fighting. Nevertheless, its core retaliatory threat amounted to a unilateral potential to destroy the Soviet Union’s first and second cities. Very few V-bombers would have survived a war scramble and penetration, yet there could be no guarantee that every single attacker could be destroyed, on the ground or in the air. The minimum retaliatory threat, the potential to destroy Moscow and Leningrad, was judged sufficient during the wait for Polaris. The British attack weight would have been negligible in the

context of general war but catastrophic in the unilateral context - sufficient to undermine the balance between the superpowers.

INTRODUCTION

TO WHAT DEGREE DID THE RAF MAINTAIN V-FORCE OPERATIONAL EFFECTIVENESS IN THE 1960s?

Britain's deterrent passed from the V-bombers to Polaris over 50 years ago. During this time there has been no detailed attempt to evaluate V-Force operational capabilities in the 1960s. This has historical consequence, as the V-Force held the strategic frontline at a crucial period during the Cold War.

The extensive V-Force literature fails to explore operational capabilities. This thesis addresses the omission, providing the first comprehensive overview of V-bomber operational effectiveness. It offers a new understanding of the nuclear strike force which dominated British defence strategy for over a decade. The thesis argues that the V-bombers' core retaliatory threat, destruction of Moscow and Leningrad, was maintained, despite the increasing obsolescence of aircraft and weapons.

The main research question generates associated questions: How did V-force operational capabilities evolve, from Skybolt's cancellation in late 1962 to the Polaris era commencing mid-1969? Did V-Force retaliatory capability always match the changing definition of viable deterrent? A deterrent based on a small force of subsonic bombers had inherent vulnerabilities; these are identified, to draw out the key components of operational effectiveness. This develops the narrative's overview of Bomber Command efforts to maintain a viable retaliatory threat in a strategic environment dominated by ballistic missiles.

Overview

During the near seven-year wait for Polaris, the V-Force operated without a long-range stand-off weapon. Should war come, V-bomber crews would have to penetrate strong Soviet defences to deliver freefall weapons or the short-range Blue Steel 1 powered bomb. This required new tactics, moving from high altitude attack to ultra low level strike. This was a low-cost, fast-track way to maximise operational effectiveness, in the absence of a long range stand-off weapon. Increasingly obsolescent aircraft and weapons were not upgraded. Instead, aircrew adopted extreme combat tactics: individual penetration at 300ft or lower, in electronic silence.

This required the highest standards of training. “Crew classification” required all crews to climb the “ladder of excellence”. Inevitably, the most successful crews received the toughest targets.

This research analysed V-Force vulnerabilities on the ground and in the air and assessed measures taken to reduce losses and so maintain a credible retaliatory threat until the handover to Polaris. The core retaliatory threat was the potential to deliver several megaton weapons on Moscow and Leningrad. The damage potential was judged severe enough (by the Joint Intelligence Committee, amongst others) to undermine the balance between the superpowers.

Research proceeded within an appreciation that the V-Force primary role was *to prevent war,* rather than to war-fight. In general war, of course, successful delivery of a few British weapons would be of little consequence. In a unilateral context, however, the potential consequences were immense and regarded as severe enough to place the USSR at a significant disadvantage. This is the background to Britain’s struggle to maintain the V-Force core retaliatory threat.

The threat also sufficed to secure the Anglo-American nuclear relationship during the 1960s. In retaining this special relationship, it provided the UK with a say in decisions concerning peace or war.

Assessing vulnerabilities

By the mid-1960s, V-Force strength had fallen from 180 aircraft to less than 100. Given the pace of missile development, vulnerabilities on the ground became increasingly prominent. This led to Quick Reaction Alert (QRA), an extraordinary regime making unprecedented peacetime demands. QRA held one bomber from each squadron fuelled, armed and ready for war.

Research of MBF vulnerabilities on the ground involved a critical examination of warning/response times and the wide-ranging measures taken to maximise the chances of escape in a war scramble. The latter included simultaneous engine-starting, Telescramble link between aircraft and HQ Bomber Command and the construction of Operational Readiness Platforms (ORPs). The crucial issue was the ability to start engines, position for take-off, scramble and reach survival distance within an extremely short timeframe.

Evaluation of MBF vulnerabilities on the ground requires a realistic context: a simultaneous launch, low trajectory IRBM strike leaving only a small group of V-bomber survivors.

The British public expected a four-minute warning, but V-Force QRA and main force generation/dispersal/regeneration exercises were based on 15 minutes' readiness (RS15). The latter was adopted as a practical working regime for the MBF, but planners appreciated that it was inappropriate in a close approach to war (tacit acceptance that a staggered launch attack giving a longer "American" warning was, in reality, a most unlikely strike mode). RS05 (Cockpit Readiness) was a more appropriate posture, but beyond reach for the entire force, even in a dire emergency: 24/7 RS05 aircraft required double crews and the V-Force lacked the required aircrew numbers. In a close approach to war, under Alert Condition 1, RS05 double-manning would apply to up to 30% of the force. This was the ultimate readiness posture – Bomber Command's maximum effort. There was no public acknowledgement that RS15 was inappropriate, as this would have amounted to an admission that most V-bombers would be vapourised on the ground or destroyed in the air near their airfields, given the more likely short warning attack mode.

Alert Level 1 offered a chance of survival for a few aircraft amongst those at 24/7 RS05. With all checks complete and poised for RS02 (engine start), Cockpit Readiness aircraft dispersed to airfields in the north and west, with slightly longer warning times, would have the best chance of escape, especially if benefitting from delayed missile burst. Simultaneous detonation was impossible to achieve – missiles would arrive over a period of some two minutes. There would be a chance of escape for aircraft "first in the queue". The research concludes that perhaps 10% of a generated and dispersed force of around 80 aircraft might survive: perhaps as few as eight V-bombers might be left, to begin their retaliatory sorties. Offsetting this small number is the fact that their combined warload might total some six million tonnes of high explosive equivalent.

Research on V-Force vulnerabilities in the air took account of contrasting circumstances: a unilateral strike, against intact defences, and general war opening with hundreds of missile strikes, which would severely degrade Soviet air defences. Furthermore, V-bomber losses would be fewer at night or in poor weather. Under all scenarios, it was vital (in the primary role) to project the maximum retaliatory threat

(and, in the unilateral context, emphasise the maximum destructive potential by targeting Moscow and Leningrad – the obvious QRA targets for “minimum” retaliatory response).

Given a small group of V-bomber survivors following a missile strike on the airfields, logic suggests that QRA targets Moscow and Leningrad should be the sole targets for *the entire V-Force* in a close approach to war. This was feasible as all operational crews stood QRA duty and trained to attack the first and second cities. This might be achieved under Plan A (the NATO war-fighting plan focused on counterforce targets, many within the greater urban areas of Moscow and Leningrad) or Plan B (the unilateral “National Plan”, based on punishment through countervalue destruction of these cities). Plan B represented the most direct projection of Britain’s status as a nuclear power. In reality, there was little difference between the two plans. The largest cities required distributed Desired Ground Zeros (DGZs) to maximise damage, whether the aiming points were military or otherwise. Either way, the outcome meant mass civilian casualties (unless the populations were already dead as a result of a tidal wave of missile strikes).

Could a few surviving V-bombers have made successful attacks? Soviet defences initially targeted high altitude threats; it took years to reconfigure them to meet a new, low level threat. As the 1960s progressed, however, improved radars, SAMs, fighters and guns eroded the low level advantage. ORB studies confirmed the likely effectiveness of low level penetration but, nevertheless, extreme combat tactics were required to penetrate coastal belt, area and point defences. Hundreds of low level-capable SA-3 SAM systems were deployed and later reinforced by more advanced SAMs. V-bomber crews were not briefed on the latest threats as their aircraft had no effective counters. Crew briefings were confined to information needed for successful penetration. Many negatives were not disclosed, including the poor prospects of surviving a war scramble, the introduction of new air defence systems and the real risk of fratricide around Moscow and Leningrad. There were also serious planning/training oversights, including a failure to brief crews to climb immediately after a war scramble, to avoid reflected shockwaves.

In the final analysis, however, there could be no absolute guarantee that *every* V-Force penetrator would be destroyed on the ground or in the air. The V-Force soldiered on as a low level nuclear strike force, in the belief that some bombers would get through.

Research methodology

This thesis is in four parts. Part 1 (chapters 1-3) is an overview of V-Force aircraft, weapons, mission and targets. Part 2 (chapters 4-7) explores MBF vulnerability on the ground (the threat, measures taken to reduce exposure, weapon system generation and the challenges of war scramble survival). Part 3 (chapters 8-10) describes Soviet air defences and tactics for low level attack. Part 4 (chapters 11-12) considers V-Force training for war and presents research conclusions.

Research involved study of the literature, relevant ORB reports and prolonged engagement with V-Force veterans and specialists over several years. A familiarisation period led to initial contact with former aircrew and groundcrew, followed by interviews and a first assessment of ORB records. A small sub-group of veterans provided commentary on the impact of operational research studies on squadron tactics, training and exercises. During the late 1950s and 1960s, a working partnership between ORB and operational crews allowed tactics to be refined, following trials of, *inter alia*, the ability to break missile lock, the protection afforded by jamming threat radars immediately prior to weapon release and issues concerning low level navigation. Some crews flew trials for the ORB, to clarify specific issues such as the impact of H_2S jamming on bombing accuracy. Equally, some ORB study outcomes were judged too sensitive to share with crews. This occasionally prompted direct orders restricting circulation. Sensitive issues included high interception rates in UK air defence exercises involving V-bombers and poor ECM performance, although most crews must have been aware of these problems. Follow-up contact with V-force veterans exposed a failure to action a number of important ORB recommendations. One noteworthy example was the failure to implement an ORB proposal to abandon Blue Steel as a QRA weapon.

Contact with former aircrew revealed the serious failure to brief crews to climb (rather than stay low) following a war scramble, to avoid destruction by reflected shockwaves. Furthermore, there was no knowledge of the “flyaway cones” recommended by ORB to avoid random bunching of aircraft. Most veterans spoke of a deep-seated conviction that deterrence would hold and that they would never have to fly a war sortie. This belief, perhaps, sat uncomfortably with living in a “close-to-war” environment. Certainly, it sat uncomfortably with senior officers who expected all aircrew to buy into the “close-to-war” spirit. Inevitably, discussions with veterans also revealed some issues which remain controversial to this day, including the extent to

which one-way missions were briefed and the disclosure (or otherwise) in Target Folders of planned missile strikes.

V-Force literature

The extensive V-Force literature focuses on the development of aircraft and weapons, the Anglo-American nuclear relationship and the politics of deterrence (see Appendix). General accounts of the Cold War period make occasional reference to the V-Force. There are many detailed accounts of the three V-bomber types, but surprisingly few autobiographies from V-Force veterans. There are some accounts of specific events, notably the Cuban Crisis and the Falklands "Black Buck" missions. There is, however, no attempt to evaluate V-Force operational effectiveness. This is a significant historical oversight and this thesis is the first detailed account of V-Force operational capabilities.

The outstanding V-Force reference work is "*RAF nuclear deterrent forces"* (1997), by Humphrey Wynn, Air Historical Branch (RAF). This comprehensive work has an excellent chronology, but V-Force war-fighting capacity is beyond its scope and Bomber Command's ORB receives only the briefest of mentions. Wynn's official history assisted the research planning. It clarified some issues in the early years, including the role of the Bomber Command Armaments School and how the V-Force might have evolved had Skybolt entered service. It also contributed to an understanding of Blue Steel's troubled life on the squadrons. There is useful commentary on V-Force deployment, the arguments surrounding its frontline strength and arrangements for dispersal. The chronology helped to relate events, especially the fact that Alert Condition 1 (with its all-important RS05 component) pre-dated main force QRA held at RS15 (indicating that the latter was NOT regarded as a viable war alert state under IRBM missile threat).

A more recent work, Matthew Jones' *The official history of the UK strategic nuclear deterrent* (Vol.1, 2017), focuses heavily on Polaris, but has useful commentary on shifts in balance between counterforce and countervalue targeting, debates over MBF size, V-Force destructive potential and, most significantly, the evolution of the "damage criterion". There is, however, little content concerning V-Force operational capabilities and measures taken to reinforce operational effectiveness during the 1960s.

Wynn and Jones do not address the author's research question in a direct manner. Beyond a small number of articles and papers, mostly authored by V-Force veterans (most notably Vulcan Navigator and Wing Targeting Officer Roy Brocklebank), coverage of V-Force war sortie capabilities is limited to a few pages in two books by Andrew Brookes, a former Captain and Flight Commander: *V-Force: a history of Britain's airborne deterrent* (1982) and *V-Force: Operations Manual* (2015). The former refers to Soviet air defence capabilities and comments on American experience in Vietnam. There are overviews of Bomber Command's ability to inflict damage during the 1960s. This information is relevant but limited in scope and detail. The more recent work includes a brief account of how a V-Force retaliatory strike would have been delivered. Roy Brocklebank was a principal source of the war sortie material.

Air Vice-Marshal Stewart Menaul's *Countdown: Britain's strategic nuclear forces* (1980) is disappointing. It is partisan, with much hostile comment directed at Labour, CND, etc. More importantly, some content is wrong. Menaul was Senior Air Staff Officer, Bomber Command Headquarters (1961-65). He makes no critical attempt to assess V-Force ability to fulfil a war mission, other than suggesting that every weapon carried would be delivered on target. Vulcan Squadron Commander Philip Goodall's *My target was Leningrad* (2015) is also disappointing, being light on operational content; his attack plan receives just a couple of paragraphs.

In contrast, aviation historian Chris Gibson's *Vulcan's hammer: V-Force projects and weapons since 1945* (2011) offers a path through the maze of concepts for advanced aircraft and weapons, together with Blue Steel Mk.1 and its stillborn variants. This documents the ingenuity of British designers and manufacturers attempting to produce viable, highly advanced weapon systems in a suffocating climate of austerity. V-Force operational capabilities are beyond this book's scope, in the direct sense, yet the operational requirements discussed provide insights into existing shortcomings.

Kristan Stoddart's *Losing an empire and finding a role* (2012) has interesting content on maximising V-Force operational effectiveness, the repeated redefinitions of "minimum deterrent", the decision to go low level, Soviet SAM defences, the character of the war sortie and post-Polaris V-Force targeting (with Roy Brocklebank, once again, a prominent source). Stoddart regards Plan A and Plan B as essentially one in their effect. John Baylis' *Ambiguity and deterrence* (1995) is also relevant. There is valuable content on early plans for a 240-strong V-Force, counterforce targeting of

Soviet long range airfields and “reorientation” to morale targets – the cities. There is some narrative on actions taken to maintain V-Force effectiveness in the absence of Skybolt.

Richard Moore’s *Nuclear illusion, nuclear reality* (2010) is an excellent overview of the dynamics of the Anglo-American nuclear relationship. Moore observes that V-bomber attack procedures and tactics “*have not been discussed in great detail in the open literature …”* This book covers the political response to the post-1962 “capabilities gap”, V-Force vulnerabilities on the ground and the British Nuclear Deterrent Study Group’s work on maintaining the effectiveness of the deterrent.

The British nuclear experience (2015), John Baylis and Kristan Stoddart, and *Planning Armageddon* (2014), Stephen Twigge and Len Scott, provide good summaries on the provision of ORPs, introduction of QRA, V-Force strength over time, dispersal policies, the development of Alert and Readiness States, the evolution of UK targeting, the incremental reduction of “minimum deterrent capability”, the “Moscow Criterion” and Britain as a second centre of nuclear decision-making. Peter Hennessy’s *The Secret State* (2010 edition) includes material from leading contributors to this thesis: Robin Woolven and Roy Brocklebank (the latter’s retaliatory strike route maps are included). With some assistance, Hennessy provides a broad sketch of a V-bomber retaliatory attack.

Important information on coordinated targeting is included in Ken Young’s *The American bomb in Britain* (2016). Lawrence Freedman’s *The evolution of nuclear strategy* (2003) includes overviews of the UK nuclear role, the Skybolt/Polaris issue (with the interesting comment on Skybolt cancellation that “The British affected surprise …”), Britain as a second decision centre and city avoidance options. Magnus Clarke’s *The nuclear destruction of Britain* (1982) demonstrates that there is little real difference between counterforce and countervalue attacks, especially within the confines of the UK. It makes interesting observations on counterforce targeting and raises the possibility of heavy attacks by Soviet bombers on the dispersed V-Force during the opening, conventional phase of war. This subject is *almost entirely absent* from departmental papers and other sources. Repeated conventional raids against MBF main and dispersal airfields would have had only one viable counter: repeated “survival scrambles” (a tactic never exercised by MBF squadrons).

The rest of the literature contributed little to the research assemblage. Alan White's *The King's thunderbolts* (2007) has useful content from 44 (Rhodesia) Squadron aircrew on QRA, dispersal exercises and experiences during the Cuban Crisis. Jim Wilson's *Britain on the brink* (2012) also deals with the Cuban Crisis.

The literature cited above has no detailed account of V-Force operational effectiveness. The literature lacks three elements:

- There is no comprehensive account of measures to maximise V-Force operational effectiveness in the 1960s (including survival on the ground, low level penetration tactics, evasive routeing, use of ECM and attack profiles).
- There is no detailed attempt to describe a V-Force war sortie, to explain how measures to enhance operational effectiveness would be applied.
- There is no examination of how human factors underpinned operational capability, through the adoption of extreme combat tactics.

This thesis is significant as it explains how Britain's airborne nuclear capability was "stretched" during the wait for Polaris. The arguments presented rest on a solid evidence base: ORB scientific analysis and recommendations, departmental papers providing an overview of planning and decision-making and the accounts of aircrew who trained to deliver the retaliatory strike.

ORB memoranda

The ORB archive spans all key operational issues: generation of V-bombers and weapons, dispersal and regeneration, penetration tactics, use of ECM and attack profiles. Some 200 ORB memoranda were reviewed and 36 were of direct relevance (see Appendix). Seven ORB reports were of particular significance: consideration of Airborne Alert in an emergency (No.197); remote overseas dispersal (No.S.26); the effect of delivery accuracy and target allocation on the effectiveness of a nuclear stockpile (No.199); minimum warning times from BMEWS (No.222); the vulnerability of the MBF to ballistic missile attacks (No.241), QRA in Bomber Command (No. 258); and BMEWS and the QRA force (No. 285).

Use of ORB memoranda presented challenges; most ORB studies examined single issues, with little or no consideration of other factors contributing to operational

outcomes. Whilst making a major contribution to the research assemblage, these reports did not assist in the task of building an overview of operational effectiveness.

Nevertheless, evidence from ORB reports and contributions from former aircrew, *when taken together*, offer insights into the degree to which operational research findings did (or did not) filter down to the squadrons, often shaping training and operational planning for war. ORB's work was rooted in squadron-based expertise. Its activities drew heavily on the experience of operational crews and, in many cases, required crews to fly specific trials. Occasionally, the outcome of trials (eg. the effectiveness of airborne jammers in breaking missile lock) confounded theoretical expectations in a positive way, so underscoring the importance of the closest scientific/operational cooperation.

Tom Kerr CB headed ORB as Chief Research Officer and Scientific Advisor to AOC-in-C Bomber Command during 1960-64, an eventful period which included the Cuban Crisis, Skybolt's cancellation and the switch to low level strike. Some of his ORB reports were blunt when confronting harsh realities, including the missile threat to the MBF. One example is Kerr's extraordinarily frank July 1963 assessment of the inadequacies of V-bomber warning devices (echoing the views of many AEOs). Strong opinions were tolerated, given the value of impartial advice. In a few cases, however, the issues raised were so sensitive that report circulation was severely restricted (even to the point of no distribution beyond HQ Bomber Command). Sometimes, the "need to know" did not include aircrew.

Tom Kerr wrote warmly of his close relationship with Bomber Command's leadership and the evidence suggests that the ORB chief's views had considerable influence, despite the fact that they were not always actioned. Kerr pressed his case with vigour, relying on scientific data rather than the wishful thinking of others. The foreword to his autobiography, *Always a challenge* (2002, self-published), was written by Sir John Charnley CB, a former Chief Scientist, RAF. He described Kerr's determination to stick to the facts: "A tenacious, well-presented defence of his strict logic was sometimes needed to persuade a critical audience to accept controversial and often unwelcome conclusions".

Kerr's willingness to express opinions certain to cause discomfort is visible in the ORB memoranda quoted in this thesis. Yet, at the same time, he was politically aware and careful not to rub salt in the wound. One example is his report on war scramble

survival in relation to warning times. Much space is devoted to the scenario based on Bomber Command's well-worked assumption of an American length warning. Here, Kerr used just a sentence to acknowledge the alternative outcome: the poor chance of survival in a low trajectory, simultaneous launch attack.

Perhaps the outstanding example of rejection of a radical proposal from Kerr was his view that the powered bomb's many inadequacies argued in favour of *arming QRA aircraft at Blue Steel stations with freefall weapons.* On another occasion, Bomber Command was desperate for broadband jammers to counter SAM radars but struggled to unlock funds. Kerr proposed cancelling two V-bombers, to pay for the ECM. This idea was rejected. Instead, Bomber Command locked horns with Whitehall and eventually emerged victorious – the evidence of success being the Vulcan 2's ECM bulge.

ORB's role was to assess V-Force and enemy capabilities and recommend to the AOC-in-C Bomber Command measures reinforcing its capacity to destroy targets. How much weight did ORB's recommendations carry? Kerr answered this question:

> My relationship with both C-in-Cs, Sir Kenneth Cross and, later, Sir John Grandy, was excellent. In addition to the normal day-to-day work, they involved me in the planning of the conferences and lecturing to the Command, Groups and aircrew … I felt it was a major endorsement of the work of the Branch and the esteem with which they regarded our work and, most of all, the frequency with which they sought our advice.

And not without good reason. ORB's significance centred on its broad spectrum of interest in the task of optimising weapon system performance. Given tough restrictions on V-Force expenditure during the wait for Polaris, this task was of singular importance. Success in maintaining operational effectiveness relied heavily on optimised alert, training and tactics, rather than new equipment, systems and more advanced weapons.

Departmental papers

Over 100 departmental papers were reviewed and 75 contributed to the research assemblage (see Appendix). Research concentrated on four areas: nuclear retaliation; vulnerability on the ground; Alert and Readiness; and penetrating defences. Important papers included:

- *Nuclear retaliation:* “Note on the strike potential of MBF”, a February 19 1958 note from ACAS to the Secretary of State for Air (AIR 19/940); “The number of V-bomber aircraft which will reach their targets”, note from Air Ministry to MoD, October 10 1958 (DEFE 25/18); and “Procedures for launching nuclear retaliation”, informal meeting, Cabinet Office, June 15 1960 (CAB 21/4756).
- *Vulnerability on the ground: “*Vulnerability of the V-bomber force”, conclusions of a meeting of the Defence Board, together with a note by J.M. Wilson, Defence Board Secretariat, April 4 1960 (DEFE 13/306); letter from office of Bomber Command AOC-in-C to D. of Ops (B&R), Air Ministry, January 24 1961 (AIR 2/17801); and “Air-delivered strategic nuclear weapons systems”, Air Force Department paper for the Long Term Strategic Nuclear Working Party, Interim Report, September 30 1971 (AIR 2/19184).
- *Alert and Readiness:* “Readiness of Bomber Command”, July 24 1958 (AIR 20/10530); “Bomber dispersals”, June 6 1961 (AIR 20/11448); “BCAR plan – Alert Conditions and Readiness States”, letter from SASO’s office to HQ, No.1 Group (Appendix A), August 18 1961 (AIR 2/17801); “The case for 36 dispersal airfields”, Air Ministry, September 11 1962, together with associated note of September 13 1962 (AIR 20/11448); “Allocation of dispersal airfields for the MBF”, minute from D. of Ops. (B&R) to ACAS (Ops.), March 1 1963 (AIR 2/16435); and “Quick Reaction Alert”, minute from Group Captain J.R.L. Blount, Air Plans, December 17 1963 (AIR 2/16435).
- *Penetrating defences*: “Defence penetration techniques: the problem of defence penetration by Vulcan aircraft at low flight altitudes during a limited conventional conflict in a non-European area”, Strike Command Development Unit Report No. 9/68 – Part 1: HQ STC Trial No.549 Phase C, Annex L, December 31 1968 (DEFE 58/90); and “The use of warning devices (Red Steer and Blue Saga) during attacks by fighter aircraft on bomber aircraft flying at high and low level”, minute, Bomber Command Chief Research Officer T.H. Kerr, July 4 1963 (AIR 14/3898).

Other sources

This part consists of three reports, 23 journal articles, eight papers and 10 other sources (see Appendix). Two reports deal with Soviet air defences (a CIA document and a study for Sandia). Articles reviewed were published in various editions of the RAF Historical Society *Journal*, including Wing Commander Rod Powell’s “EW in the V-Force era”, *Journal 28* (2003). Editions of *Air Power Review* were considered,

including the Paul Graham article “RAF nuclear deterrence in the Cold War”, *Air Power Review*, Vol.10, No.1, Spring 2007, and Peter Hudson’s “A view from Whitehall”, Deterrence Special Edition, Vol. 20, No.2, Summer 2017, together with Clive Richards’ “Time is no longer our ally: RAF Bomber Command, deterrence and the transition to war, 1955-62”, Vol.21, No.2, Summer 2018.

Robert Norris and Hans M. Kristensen’s “The British nuclear stockpile, 1953-2013”, in *The Bulletin of the Atomic Scientists,* was a welcome reference tool, as was Jonathan Ayles’ article on Blue Danube, “First Waltz”, *International Journal for the History of Engineering and Technology,* Vol.85, No.1, January 2015. Two major contributors to research for this thesis, Roy Brocklebank and Norman Bonnor, authored valuable papers: “How did Bomber Command prepare for war?”, *Flypast,* October 17 2008, and “The V-Force: 1955 to 1966: Navigation at 50,000 and 500ft”, for the 2014 Newark V-Force reunion.

Significant papers also included Norman Bonnor’s “Blue Steel – the V-Force’s stand-off bomb” (undated) and Mike Fazackerley’s WE.177 paper “Weapon X: the bomb with no name” (unpublished). Other notable papers included Richard Moore’s “Pedantic glossary of British nuclear weapons”, Peter Jones’ “The history of the UK strategic deterrent” (1999) and James T. Quinlivan’s RAND paper, “Soviet strategic air defense” (1989).

Prominent amongst the other sources is the record of the King’s College, London/Institute of Contemporary British History 2014 Witness Seminar, “Defence through deterrence: British policy during the 1960s and 1970s”, with participants including research contributors Roy Brocklebank, Peter West and Robin Woolven.

V-Force veterans

There is a significant human dimension to the research question, as V-Force operational effectiveness in the 1960s relied heavily on extreme combat tactics. The research included an extensive dialogue with former V-Force aircrew and groundcrew. Seventy-two contributors were identified. The large number of interviews planned reflected the long service life of the V-Force and the need to cover five crew positions. Some aircrew who served in the 1970s V-Force were included, as their observations on capability in that decade offered insights into potentially stronger capability in the preceding decade (eg. the outstanding performance of Vulcan crews in US Red Flag battle exercises). Some contributions may represent the sole

opportunity to gather certain information (eg. an account from the last surviving Nav/Radar to have dropped a British hydrogen bomb, descriptions of live trial firings of Blue Steel and an outline of the contents of RAF Waddington's war room, or "Vault").

This oral history research programme proceeded following King's College, London, ethical approval (classification: "Minimal Ethical Risk"). Work began in 2018, at a rate of up to four interviews monthly; 76 interviews were conducted over a three-year period. During this time, contact was lost with some contributors. Others failed to respond with approvals and some withdrew. This material was excluded from the research assemblage. Fifty-nine revised/approved interviews remained, from 55 contributors (two gave second interviews and another gave three).

These interviews were assessed for content. There was some natural variation in research value due to degree of recall, level of interest in the project, communication abilities, etc. A few interviews contained little information of direct relevance; others were repetitious. Following assessment, 44 approved interviews, from 40 contributors, joined the research assemblage. The contributors were: 18 Pilots, 14 Navigators, six AEOs, a groundcrew Crew Chief and a nuclear weapons historian. Fifteen contributions were approved in 2018, 12 in 2019 and 13 in 2020 (see Appendix).

A subgroup of 10 contributors emerged who wished to further engage with the project, through on-going dialogue and the provision of additional material: contemporary documents, conference papers, articles and correspondence on issues of particular interest (eg. quality of ECM, Blue Steel safety and QRA duty). This highlighted (and, in some cases, resolved) disputed matters, such as the detonation timing of WE.177B. A few issues were not resolved, notably the question of whether Target Folders disclosed planned missile strikes on MBF targets. Such issues are acknowledged in the text.

Some conflicting views were resolved whilst cross-checking contributions; this was assisted by the relatively small number of squadrons and the network of contacts between former crew and squadron members – a factor which promoted a spirit of cooperation. A small Reading Group (Squadron Leader Roy Brocklebank, Air Commodore Norman Bonnor and Dr Robin Woolven) received text for comment,

where relevant. All 10 major contributors received full text drafts, to confirm approval of all material provided.

Dialogue with aircrew veterans and others gave a new dimension to this research. Issues raised by research review of reports and documents were discussed with major contributors, in some cases following the provision of copies of ORB studies on, for example, war scramble escape potential. Whilst these reports contained some surprises for veterans, consideration of information from both oral and documentary sources lends strength to the view that a close relationship existed between ORB and the squadrons. Research studies reflected operational concerns about aircraft, weapons and tactics. The results of much of ORB's work filtered back into the training and exercises for operational crews. The impact was monitored and measured through ORB review of exercises requiring the generation, dispersal and regeneration of freefall and Blue Steel systems.

This author's ongoing engagement with veterans revealed that Bomber Command had been highly selective in what was shared with crews, with non-disclosure of a range of sensitive information (although, in some instances, gaps in knowledge appear to be the product of omissions and inertia, rather than deliberate non-disclosure). Understandably, aircrew lacked the "big picture"; it was important to take this into account when assessing content. For example, veterans lacked a full appreciation of poor survival prospects in a war scramble, the dangers of fratricide around targets and the use of aircraft as decoys. At the same time, a relatively large group of contributors ensured good coverage across the crew positions and extensive opportunities to canvass views on matters such as ECM quality, the ability to reach targets, belief in the deterrent and the likelihood of being called to fly a war sortie.

V-Force operational planning had an undeniable element of ruthlessness, driven by the need to maximise operational value from modest assets. Crews were told only what they needed to know to fly the war sortie and deliver weapons on targets. Crews were forbidden to discuss targets amongst themselves. Members of the major contributors sub-group having wider knowledge (notably Roy Brocklebank, Norman Bonnor, Robin Woolven and John Huggins, together with nuclear weapons historian Mike Fazackerley) generously shared their perspectives during analysis of the research assemblage.

Major themes

The Soviet military, no matter how capable, could not provide an absolute guarantee that all V-bombers would be destroyed on the ground, or that every V-bomber survivor would be destroyed in the air before weapon release. This thesis argues that a small group of dispersed V-bombers could have survived an IRBM strike, to begin a retaliatory sortie. They would have flown ultra low, as single penetrators, and some could have succeeded in releasing megaton class weapons on Moscow and Leningrad. This capability combines projection of the most powerful retaliatory threat available with the highest destructive return from very few weapons. It was felt unnecessary to engage in major upgrades of the V-Force during the wait for Polaris; high expenditures would offer only modest returns (perhaps an additional two or three weapons on the principal targets).

The primary purpose of the British airborne deterrent, with its limited capability continuously eroded by advancing Soviet offensive and defensive capabilities, was to make an independent, albeit modest contribution to the prevention of war, rather than to war-fight following the failure of deterrence. Its potential to deter, through a credible core threat to destroy the first and second Soviet cities, was regarded as sufficiently severe until the advent of Polaris (the ideal small-scale deterrent, combining a secure platform with almost certain warhead delivery). V-Force war-fighting potential would have had little consequence in the catastrophe of general war, but its unilateral potential to undermine the superpower balance secured the UK's position as a second centre of nuclear decision-making. It contributed to deterrence and guaranteed Britain's say in whether there should be peace or war.

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BRITAIN'S AIRBORNE DETERRENT

This opening chapter provides the context: the pressure on Britain to become a nuclear power, the focus on the manned bomber to achieve this end, the new bombers, their weapons and targets. The vulnerabilities of the subsonic bomber deterrent, on the ground and in the air, are introduced, as are the weaknesses of British freefall weapons and the Blue Steel Mk.1 powered bomb. With the Skybolt system cancelled, the challenge of maintaining V-Force operational effectiveness is discussed.

The new bombers

On August 10 1945, the day after the plutonium bomb exploded over Nagasaki, Prime Minister Clement Atlee established GEN 75, a Cabinet Committee charged with establishing Britain as a nuclear power. The obvious counter to an atomic bomb on London was an atomic bomb on the enemy capital.[1] The race to create a credible nuclear deterrent was under way, with no question over means of delivery. The national interest required a nuclear weapons system ready by the second half of the 1950s.[2] The bomber was the UK's fastest route to an operational deterrent.[3]

Three bomber types emerged: the advanced Vulcan and Victor and the Valiant "interim" type.[4] During 1953, Air Chief Marshal Sir Ronald Ivelaw-Chapman, Deputy Chief of the Air Staff (DCAS), minuted the Secretary of State for Air, stressing MBF significance and adding: "… for deterrence, the biggest force we can afford is the least we should provide."[5] In November 1954 he added: "… one thing that is clear … is the overriding importance of the MBF. In peace, it is the force which can provide the necessary power behind our voice in international affairs and in war it is the one force with which we could strike a worthwhile blow against our enemies."[6]

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[1] Chris Gibson, *Vulcan's hammer: V-Force projects and weapons since 1945* (Manchester/UK: Hikoki Publications, 2011), 9-10.
[2] Humphrey Wynn, "Early air-carried, air-launched weapons", The history of the UK strategic deterrent, Royal Aeronautical Society, March 17 1999.
[3] Paul Graham, "RAF nuclear deterrence in the Cold War", *Air Power Review*, Vol. 10, No. 1 (Spring 2007): 50-75.
[4] Gibson, *Vulcan's hammer*, 17.
[5] AIR 20/7560, DCAS/1096, S.534, 30.1.1953.
[6] Humphrey Wynn, *RAF nuclear deterrent forces* (London: The Stationery Office,1997), 71.

What would that blow consist of? The priority then was to destroy Soviet nuclear forces capable of striking the UK. A draft paper of 1955 identified 103 Soviet bomber bases 750-1,500 NM from the UK and posing a threat to Britain. This paper also referred to a May 1955 Bomber Command Directive underlining the need to destroy the enemy's will to continue the war by attacking population centres. Seventy-two Soviet cities were considered as targets (37 within 1,500 NM of the UK and 35 between 1,500 and 2,000 NM).[7]

Given the immense cost of building a British bomb and delivery system, the Air Ministry explored unconventional, lower cost alternatives. One, "Blue Moon", was a crewless "expendable bomber" capable of reaching Moscow.[8] Blue Moon waned due to the lack of a reliable guidance system. The need for a workable deterrent was too important for radical experimentation. Many futuristic projects existed on paper, but Bomber Command's daily reality was more akin to World War 2. The early 1950s strategic bombing force consisted of Avro Lincolns, a Lancaster derivative unable to attack Soviet targets.

In January 1948 Avro received clearance to proceed with Vulcan prototypes; this bomber first flew on August 30 1952. Two weeks previously, Avro received a contract for 25 production aircraft, followed by a second order for 37. The RAF took delivery of its first Vulcan, XA 897, on July 20 1956. Handley-Page's H.P. 80 became the crescent-wing Victor, which first flew on December 24 1952; an initial order for 25 was placed that June. The Victor entered service in 1958. The Valiant was the first of the three to become operational (February 1955); it saw action during the 1956 Suez Crisis. In the same year, SA-1 SAMs were deployed around Moscow. The more capable SA-2 then appeared; by 1958 there were some 600 SA-2 sites.[9] Growing Soviet defensive and offensive capabilities would challenge the RAF's new bombers.

V-Force operational effectiveness was more than a simple function of force size. Clive Richards (2018) identified three factors underpinning MBF credibility: "… the ability to disperse and protect the bomber force in time of war … the development of robust transition to war procedures and the maintenance of a proportion of Bomber

[7] AIR 20/11552, "The operational effectiveness of the V-bombers", preliminary draft, OR. 16 (55) 5, July 7 1955.
[8] Gibson, *Vulcan's hammer*, 12-13.
[9] **"**Soviet Bloc air and missile defense capabilities through mid-1967", *National Intelligence Estimate Number 11-3-62*, 7-9, October 31 1962.

Command at a high state of peacetime readiness, capable of retaliating in the event of a surprise pre-emptive attack."[10] The new bombers, however, were exposed to destruction on the ground. The true measure of V-Force strength was not its size but, rather, the proportion of the force surviving pre-emptive attack. These survivors would then run the gauntlet of the Soviet coastal defence belt, fighter, SAM and gun area defences and, finally, point defences around targets. Furthermore, each British bomber carrying a freefall weapon would be exposed to at least two nuclear bursts, one over its home airfield and, subsequently, detonation of its own weapon over the target. Whilst they would almost certainly arrive after an opening missile exchange, they would be the first strategic bombers attempting penetration.

"Special Weapons"

British nuclear weapons were freefall, with the exception of Blue Steel Mk. 1, the "powered bomb" or stand-off weapon. "Blue Danube", 16 kilotons (KT), was the UK's first nuclear weapon. There was also "Red Beard", a tactical weapon (10-15 KT). Pressure for the early introduction of "megaton class" weapons (c. 0.5 MT) resulted in a handful of "Violet Club" interim "megaton" bombs (400 KT), but "Yellow Sun" Mk. 1 (400 KT) was the RAF's first practical high yield weapon. Its successor, Yellow Sun Mk. 2, was a true megaton weapon (1.1 MT). During the 1960s, the V-Force had two strategic freefall weapons: Yellow Sun 2 and its long-lived successor, the WE.177B laydown bomb (450 KT). In addition, 40 V-bombers (five squadrons) were armed with Blue Steel (1.1 MT), while 24 Valiants (three squadrons), assigned as the Tactical Bombing Force (TBF) to the Supreme Allied Commander, Europe (SACEUR), carried American "Project E" weapons, including the Mk.43 laydown bomb. By end-1958, around 58 Blue Danube bombs and five Violet Clubs were available. The stockpile had increased to around 200 British-made weapons by late 1961, including Red Beard and the Yellow Sun 2 hydrogen bomb.[11]

It was intended to arm the future V-Force with stand-off weapons, allowing the bombers to stay outside defended airspace. This was demonstrated by significant early work on systems such as "Blue Boar". Yet, 30 years on, Vulcans were still armed with WE.177 freefall bombs and British fast jets with a nuclear strike role continued to carry these weapons until the late 1990s. This contrasts with British innovation in

[10] Clive Richards, "Time is no longer our ally: RAF Bomber Command, deterrence and the transition to war, 1955-62", *Air Power Review*, Vol. 21, No. 2 (Summer 2018): 36.
[11] Richard Moore, *Nuclear illusion, nuclear reality: Britain, the United States and nuclear weapons, 1958-1964* (Basingstoke (UK)/New York: Palgrave Macmillan, 2010), 78.

advanced weapon design, which was outstanding during the early post-war period. Blue Boar, a potential Blue Danube successor, was a TV-guided stand-off weapon, with a 25 NM range. It was cancelled in 1954 as the technology of the time could not support the concept. Avro and other companies produced portfolios of advanced concepts for powered weapons, supersonic delivery systems and even some designs with Vertical Take-Off and Landing (which, certainly, would have offered a novel solution to dispersal).[12]

Early freefall nuclear weapons were unsophisticated; some required "last-minute loading" (LML) of cores. The lack of a British low level weapon until late 1966 exposed bombers to SAM defences. As for the powered bomb, Blue Steel Mk.1 disappointed. It was liquid-fuelled, difficult to generate, unreliable and required dangerous High Test Peroxide (HTP). Blue Steel lacked the operational qualities required in a rapid response environment. What the V-Force needed, from 1963 onwards, was an advanced, solid-fuelled, reliable stand-off weapon with a range of at least 1,000 NM. However, long-range Blue Steel 2 was cancelled, as was the ALBM Skybolt, leaving five Blue Steel 1 squadrons with a weapon offering only 50 miles range at best when launched at low level.

Blue Danube and the nuclear rainbow

Blue Danube's first live drop was on October 11 1956.[13] It was huge – just over 24 ft long, with a maximum width of 62 in. Over half its weight consisted of 2½ tonnes of conventional high explosive. Jonathan Aylen (2015) noted that many commercial firms contributing to Blue Danube had no idea of end use: "The weapon system was built on the back streets of northern towns, such as Leeds, Barnsley and Mansfield, and in the southern suburbs, such as Ilford, Weybridge and Shoreham, as much as the more familiar sites of Woolwich, Aldermaston and Burghfield."[14]

In August 1953, less than a year after the first British atomic test, the Americans detonated their first thermonuclear device, with the Russians hard on their heels. On

[12] Gibson, *Vulcan's hammer*, 55-57.
[13] AVIA 65/1114, "Serviceability of Blue Danube Mk. I and Mk. II", note by Air Ministry, File No. 407/090, November 29 1956.
[14] Jonathan Aylen, "First waltz: development and deployment of Blue Danube, Britain's postwar atomic bomb", *International Journal for the History of Engineering and Technology*, Vol. 85, No. 1 (January 2015): 31-59.

June 16 1954, the British Government authorised production of thermonuclear weapons (announced in the 1955 Defence White Paper).[15]

Planning for megaton weapon trials in the Pacific began in 1955, with tests during 1957-58. Valiants of 49 Squadron, operating from Christmas Island, dropped weapons off Malden Island.[16] The last tests, "Grapple Z", included two megaton airdrops, with yields in the 2.5-3 MT range.

Blue Danube was first assembled in 1953. No aircraft could carry it until April 1954, when 1321 Flight was formed to integrate Valiant and weapon.[17] Five Blue Danube bombs were available in 1954, increasing to 10 in 1955, 50 in 1956 and 58 in 1957 (when the UK stockpile totalled 928 KT). Blue Danube (£500,000 per round) remained in the stockpile until 1962.[18] Nuclear weapons historian Mike Fazackerley noted that the bomb was hand-crafted: "It has been said that Blue Danube can hardly be described as a weapon. It was more a collection of laboratory experiments. Every example was built individually and each completed bomb differed from the next."[19]

Violet Club was a step change. This interim megaton weapon consisted of a "Green Grass" 400 KT warhead in a Blue Danube casing. Moore (2010) notes the safety issues surrounding a large fission weapon: "…the danger existed of super-criticality in the event of an accidental deformation of the warhead."[20] The first Violet Club reached the RAF in March 1958; five were delivered and, by the end of the year, a few more may have been assembled but production ended in favour of Yellow Sun 1. Violet Club was withdrawn in 1959.[21]

Those in the know regarded five Violet Clubs as five too many. Virtually everyone was terrified of this weapon. It had to be assembled on the station from which it would be used; road transport was limited to that required to move it from assembly point to

[15] Sir Winston Churchill, Statement on Defence 1955, Command Paper 9391, *Hansard*, Vol. 537, 1893-2012, March 1955.
[16] Wynn, *RAF nuclear deterrent forces*, 222.
[17] Gibson, *Vulcan's hammer*, 47-48.
[18] Robert S Norris and Hans M. Kristensen, "The British nuclear stockpile, 1953-2013", *Bulletin of the Atomic Scientists*, 69:4 (2013): 69-75, DOI: 10. 1177/0096340213493260 (sources include: John R. Walker, "British nuclear weapons stockpiles, 1953-1978, *RUSI Journal,* Vol.156, No.5 (October 2011): 66-72.
[19] Mike Fazackerley, Canberra Pilot and nuclear weapons historian; amongst documents/text provided: 15/11/20.
[20] Moore, *Nuclear illusion, nuclear reality*, 104.
[21] Richard Moore, "The real meaning of the words: a pedantic glossary of British nuclear weapons", Mountbatten Centre for International Studies, *UK Nuclear History Working Paper No.1* (March 2004).

storage building. The integrity of its large hollow sphere of highly enriched uranium was defended by a filling of some 20,000 steel ball-bearings, increasing bomb weight to 11,250 lbs. Chris Gibson (2011) points out that this exceeded the limits of the Vulcan's bomb release mechanism, so ruling out flight with the safety devices in place: "Even ground-running of engines was frowned upon … for fear that the bung would fall out, followed closely by 20,000 steel balls." A war sortie with this weapon would require the bung to be removed, allowing the ball-bearings to "drain" – which took half an hour at best. The ball-bearings had the unpleasant habit of sticking to the rubber liner within the sphere. Cold weather caused ball-bearings to freeze together, rendering the weapon useless.[22] Nevertheless, these risks were taken to achieve a "megaton" capability a few months earlier than would otherwise have been the case.[23]

Nuclear weapons historian Mike Fazackerley regards Yellow Sun 1 as the RAF's first practical nuclear weapon: "It represented a big advance in operability, although it still took a lot of time and effort to generate for an operation."[24] Yellow Sun 1 entered the stockpile in 1958 and had exited by 1963. This 7,000 lbs, 400 KT weapon was carried by Vulcan and Victor B.1/B.1A aircraft.[25] The British stockpile included 37 Yellow Sun 1 weapons by 1961.[26] Whilst a big advance, Yellow Sun 1 also had the risks associated with a large fissile shell – the Green Grass physics package, again protected by a filling of ball bearings. Air Commodore Owen Truelove (2001) recalls a test of mathematical ability and patience: "Yellow Sun 1 had 6,500 ball-bearings in it. I know that because I dropped them all over the hangar floor and had to personally count every one back in!"[27]

Red Beard, a compact tactical weapon, had four variants: the Mk. 1, up to 15KT; a naval weapon up to 25KT; No.1, a Red Beard for high altitude delivery by Vulcans, Victors and Canberras; and No. 2, for low altitude bombing system (LABS) delivery by Buccaneer and similar aircraft. Red Beard entered service in 1962 and continued until superseded by WE.177 tactical variants.[28]

[22] Gibson, *Vulcan's hammer*, 50-51.
[23] Wynn, *RAF nuclear deterrent forces*, 249.
[24] Mike Fazackerley; documents/text provided: 15/11/20.
[25] Norris and Kristensen, "The British nuclear stockpile", 69-75.
[26] Moore, "A pedantic glossary of British nuclear weapons".
[27] Air Commodore Owen Truelove, afternoon discussion, RAF Historical Society, *Journal 26* (2001): 96.
[28] Gibson, *Vulcan's hammer*, 49.

Yellow Sun 2 was a vast improvement on Yellow Sun 1. The initial order was for 24 with the 1.1MT "Red Snow" physics package, at £500,000 each. Yellow Sun 1 had cost £1.2 million per round.[29] Yellow Sun 2 was the principal British freefall weapon from 1961 to 1967. Its Red Snow package, a modified Mk.28 American warhead developed for the "Hound Dog" air-launched weapon, was a true fusion weapon. Yellow Sun 2 was carried by Vulcans and Victors, until gradually replaced by the laydown WE.177B bomb from late 1966. According to Norris and Kristensen (2013), in that year the British stockpile (133 MT) included 110 Red Beard tactical weapons, 35 Red Beard naval weapons, 86 Yellow Sun 2 thermonuclear bombs and 40 Blue Steel weapons, also with Red Snow warheads.[30]

Mike Fazackerley describes Yellow Sun 2 as "a much bigger advance in weapons technology, having benefitted from American expertise in miniaturisation."[31] Its Achilles Heel was that it needed an altitude of at least 11,000 ft for release, a requirement incompatible with the new low level war mission, introduced during 1963-65 following Skybolt's cancellation. Freefall aircraft carrying Yellow Sun 2 had to "pop up" into the SAM kill zone to release.

The MBF in Autumn 1964 consisted of four squadrons of Victors (32 bombers) and nine of Vulcans (72 aircraft), with 40 of the 104 bombers armed (or to be armed) with Blue Steel. There were also 48 Canberras in Germany and 24 Valiants in the UK assigned to SACEUR and armed with American weapons.

The Bomber Command Armament School (BCAS), established in 1953 at RAF Wittering, introduced Blue Danube and later weapons into service. This included training ground staff and aircrew in the storage, servicing and operation of nuclear weapons. Wittering accommodated a stock of weapons, BCAS, an Atomic Weapons Trials Flight and 138 Squadron, the first Valiant unit.[32]

"Project E" weapons

British-built nuclear weapons were supplemented by American bombs. In December 1956 the CAS, Sir Dermot Boyle, received an offer of "E" weapons, together with an

[29] AVIA 65/818, "Note on nuclear weapons ordered for the RAF", July 8 1959.
[30] Norris and Kristensen, "The British nuclear stockpile", 69-75.
[31] Mike Fazackerley; documents/text provided: 15/11/20.
[32] Wynn, *RAF nuclear deterrent forces,* 87-99.

invitation to coordinate strike plans.[33] The first American weapons supplied were Mk.5 and Mk.7 variable yield bombs. Main force Victors and Vulcans ceased carrying E weapons in 1962. B.28 and B.43 bombs armed the NATO-assigned Valiants. [34]

E weapons were under dual control (in effect, American guardianship) and held only at selected RAF stations. American weapons first arrived at RAF Honington in September 1958, followed by RAF Waddington and RAF Marham in the final quarter.[35] NATO-assigned Valiants received 48 B.28/B.43 weapons, available during the 1960-65 period. Subsequently, NATO Canberras (1965-72) and Phantoms (1972-76) carried these weapons.[36]

Under US law, Custodial Officers had to "retain physical possession and custody of all US atomic weapons," with transfer to the RAF only on authority from the US Chiefs of Staff, through SAC.[37] American insistence on dual control meant that E weapons were of limited value; the RAF had to accept obvious disadvantages concerning dispersal and readiness.

These drawbacks and the growing availability of British weapons eventually led to the phase-out of Project E – ending in July 1961 at Honington and December 1962 at Waddington. However, the 24 TBF Valiants at Marham and assigned to SACEUR continued to carry E weapons until these aircraft were grounded in January 1965.[38]

The powered bomb

The case for a powered bomb, allowing V-bombers to stay outside point defences, was recognised as early as 1953. The goal was a weapon system immune to interception and the outcome was Blue Steel 1.[39] Air Vice-Marshal Stewart Menaul (1980) described Blue Steel 1 as one of the world's most advanced weapons of its time.[40] Chris Gibson (2011), however, wrote that Blue Steel's development was such a complex task that "the high technology of 1955 (had) become the old hat of 1963."[41]

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[33] Ibid, 254, 604.
[34] Moore, "A pedantic glossary of British nuclear weapons".
[35] AIR 2/17333, "Deliveries of Project E weapons", letter from Major-General W.H. Blanchard, Commander SAC 7th Air Division, to Air Ministry, September 17 1958.
[36] Norris and Kristensen, "The British nuclear stockpile", 69-75.
[37] Stephen Twigge and Len Scott, *Planning Armageddon: Britain, the United States and the command of Western nuclear forces, 1945-1964* (Abingdon (UK)/New York: Routledge, 2014), 105.
[38] Wynn, *RAF nuclear deterrent forces,* 625.
[39] Gibson, *Vulcan's hammer*, 68.
[40] Air Vice-Marshal Stewart Menaul, CB, CBE, DFC, AFC, *Countdown: Britain's strategic nuclear forces* (London: Robert Hale, 1980), 109.
[41] Gibson, *Vulcan's hammer*, 65.

Blue Steel had a speed exceeding Mach 2 and a high altitude range of 100NM plus (some sources claim 150NM) but this reduced to 35NM to 50NM at best for low level launch. Its inertial guidance could not be jammed. Blue Steel entered the stockpile in 1962 and remained in service until 1969.[42] According to Richard Moore, a deliverable stockpile of 48 was produced.[43] Air Vice-Marshal Menaul defended its value: "Its range, initially, was sufficient to enable the aircraft to stand well outside the SAM defences … but it was realised that it would not enjoy immunity indefinitely … Blue Steel was an interim weapon, leading logically to the ALBM, and filled the gap admirably in the high level role in the interim period."[44] Unfortunately, the carriers had to go to war at low level, if they were to stand any chance of survival.

Blue Steel entered service in the third quarter of 1962; it was to be the only stand-off strategic weapon to reach the V-Force. Blue Steel 2 had been cancelled nearly three years earlier, on January 1 1960, in favour of the doomed Skybolt ALBM. All eyes were on Skybolt and a vision of 72 Vulcans, each carrying two ALBMs and offering an equivalent deterrent threat to that posed by the 144 V-bombers originally agreed in August 1957 [45]. It seemed straightforward: Blue Steel 1-armed V-bombers would be fully effective until 1966, when Skybolt would open a new chapter – another life extension.

Blue Steel 1's late entry into service reflected trials-related issues, the need to modify aircraft and problems with Red Snow (not ready until March 1962, at the earliest). There was acute time pressure, given the powered bomb's expected short life on the squadrons before replacement by Skybolt in 1966.[46] This was not to be, but, meanwhile, another problem loomed – the rapidly expanding Soviet air defences. The Ministers of Defence, Aviation and Air met on September 26 1961 to discuss Blue Steel's problems. Two days later, the Air Ministry sent an assessment of V-Force capabilities against the Soviet defences to the Minister of Defence:

> There is no doubt that the high priority given by the Russians to SAMs has made it more difficult for our bombers to penetrate to their targets. This may mean that in the period before we get Blue Steel we should not be able to achieve quite the same level of destruction as we expected a year or 18 months ago … however, we do not believe that the reduction in the effectiveness of the V-Force will be very serious.[47]

[42] Norris and Kristensen, "The British nuclear stockpile", 69-75.
[43] Moore, "A pedantic glossary of British nuclear weapons".
[44] Menaul, *Countdown*, 110.
[45] Wynn, *RAF nuclear deterrent forces*, 314-333.
[46] DEFE 25/86, minutes of the Defence Committee meeting, January 12 1962.
[47] Wynn, *RAF nuclear deterrent forces,* 209-210.

The Air Ministry offered three reasons to support this claim: SAM effectiveness would be reduced by ECM, tactical routeing would avoid known SAM sites and the number of bombs allocated to the most important (and heavily defended) targets was increased. Interestingly, this Air Ministry assessment raised the option of low level attack, to exploit lack of Soviet capability below 5,000 ft, whilst, at the same time, acknowledging the lack of a low level freefall weapon at that point. It concluded by stating that the AOC-in-C Bomber Command was "quite confident that the MBF, even operating without the Americans, is still in a position to destroy the greater part of the targets at which it would be launched. In an operation with the Americans, there should be no reduction in our joint ability to reach the targets, though, of course, Russian SAM capability would necessarily impose heavier casualties on both of us."[48]

Fuel was Blue Steel's principal weakness. The powered bomb was a bi-fuel weapon. Its Stentor twin-chamber rocket engine used HTP and kerosene. HTP's high density allowed more fuel to be carried, but it had severe operational disadvantages as an oxidiser. HTP had a fearsome, well-deserved reputation – a skin splash caused severe burns unless washed off in seconds. Careful handling was essential, requiring special equipment and protective clothing. Water tanks were provided; any operator receiving a splash was expected to jump in.[49] At the strategic level, a liquid-fuelled weapon system had inherent disadvantages in a political and military environment dominated by the need for rapid response.

It was not just a matter of fuel. Many other issues dogged Blue Steel, thermal batteries for one. John Baylis (1995) noted the Nuclear Weapons Safety Committee's refusal to accept thermal batteries fitted into Readiness Blue Steel missiles. "In their view, it would only be possible on safety grounds to insert the batteries at the last possible moment before take-off. This, however, was likely to take more than 10 minutes to achieve, negating the procedures designed to improve the rapid reaction arrangements of the V-bombers carrying the missile."[50] The missile's Inertial Navigation System (INS) also needed time to set up and required delicate handling.

[48] Ibid, 210-211.
[49] Gibson, *Vulcan's hammer,* 69-70, 86.
[50] John Baylis, *Ambiguity and deterrence: British nuclear strategy 1945-1964* (Oxford: Clarendon Press, 1995), 350; Wynn, *RAF nuclear deterrence forces*, 218-219.

Reservations grew and the fundamental value of the weapon was questioned. In a letter to the CAS (Marshal of the Royal Air Force Sir Thomas Pike) on July 30 1963, Bomber Command AOC-in-C Sir Kenneth Cross spelt out Blue Steel's operational inadequacies as he saw them: the chance of a powered launch no better than 40% and the probability of a missile reaching the target after launch of about 75%. Of six weapons on Readiness, two or at most three would be launched and the remainder would have to be carried over the target and dropped freefall: "Of those launched, one will probably fail to reach the target."[51] John Baylis offers a blunt summary of the situation: "Having to carry half the number of missiles over their target before launching them destroyed the whole purpose of developing Blue Steel, which was to provide a stand-off capability …"[52]

The troublesome child

The 35 ft-long Blue Steel was designed for release at 40,000 ft. When the rocket ignited, it accelerated to Mach 2.3, climbed to 59,000 ft, then entered the final cruise climb, using Stentor's smaller chamber to attain 70,000 ft. When the rocket cut, the missile began its terminal dive. Blue Steel first reached 617 Squadron, then 27 and 83 – the other Vulcan squadrons at Scampton – followed by 100 and 139 Victor squadrons at Wittering. Julian Grenfell, a 27 Squadron AEO, remembers Blue Steel's arrival: "At first, we saw it as the ideal weapon… We wouldn't have to go through the target defences. The downside was that the weapon wasn't Blue Steel Mk. 1. In real terms, it was a productionised test version."[53] Nuclear weapons historian Mike Fazackerley agrees: "Blue Steel 1 was a prototype in service … and it was pushed into service very quickly."[54]

According to Fazackerley, an extended range Blue Steel (with wings and boosters) "would not have resolved its fundamental problem: as a liquid-fuelled weapon, it was impossible to generate quickly in an emergency." [55] As might be expected, Blue Steel's entry into service was overshadowed by cancellation of its intended successor, Skybolt. Macmillan returned from Nassau with Polaris. Skybolt's demise was still raw on February 14 1963, when a Press visit to Scampton was hosted by the

[51] Wynn, *RAF nuclear deterrence forces,* 218-219.
[52] Baylis, *Ambiguity and deterrence*, 350.
[53] Julian Grenfell, Vulcan AEO, 27 Squadron, 617 Squadron, RAF Scampton; interviewed: 10/12/18.
[54] Mike Fazackerley; documents/text provided: 15/11/20.
[55] Ibid.

AOC-in-C Bomber Command. Introducing the powered bomb, he managed to avoid mentioning Skybolt.[56]

Arming a V-bomber with Blue Steel tested patience. The weapon had to be removed from storage and fitted with a warhead, the aircraft had to be prepared and missile and aircraft mated (the latter a four-hour process at best). Following post-load checks, the missile would be fuelled with HTP/kerosene and crew combat checks completed. This time-consuming process involved several teams and specialised equipment. The challenge is explained by Stoddart (2012): "There were 471 connectors between the missile and aircraft and all had to work to ensure operation. This meant loading took an estimated two and a half hours before compatibility checks could begin, and if anything was found to be non-functional, the entire process had to be repeated."[57]

One major headache was the time needed to recover fuelled missiles. Given that 18 of 24 missiles arming a Wing were brought to "Combat Launch" condition, and given the availability of one drying unit (with drying taking at least 24 hours per missile), recovery would take over two weeks! Given four drying units, this could be reduced to about four working days.[58]

Other problems arose from Blue Steel's complexity. Yet, commonsense and ingenuity overcame many difficulties, including INS alignment, as confirmed by Norman Bonnor: "We had to assume a scramble take-off, so we could not start and align the INS on the ground. We started it in the climb and levelled the platform by forcing inertial velocities to equal the Doppler radar ('Green Satin') velocities."[59]

In his July 1963 letter to CAS Sir Thomas Pike, outgoing Bomber Command AOC-in-C Sir Kenneth Cross set out the painful realities associated with Blue Steel. Its generation could not be reduced much below seven hours even without defects, and could take 10-15 hours. He was gloomy about future prospects: "The reliability of the weapon may, of course, improve with more experience, but I am doubtful if we can

[56] Wynn, *RAF nuclear deterrent forces*, 216.
[57] Kristan Stoddart, *Losing an empire and finding a role: Britain, the USA, NATO and nuclear weapons, 1964-70* (Basingstoke (UK)/New York: Palgrave Macmillan, 2012), 102.
[58] AIR 14/4342, Bomber Command, Operational Research Branch, Memorandum No. 273, "Generation of the 'Blue Steel' weapon system in Readiness exercises," August 1963.
[59] Air Commodore Norman Bonnor, FRIN, FRAeS, Vulcan Nav/Radar, XV Squadron, RAF Cottesmore (1961-64); 100 Squadron (Blue Steel), RAF Wittering (1964-66); Powerpoint: "Blue Steel, the V-Force's stand-off bomb."

expect anything significant… there are so many basic faults in Blue Steel from a Readiness aspect that it is very doubtful whether they can be overcome."[60]

Later that year, on October 4, Sir John Grandy, the new AOC-in-C, attended Scampton to watch a Blue Steel loading and QRA exercise. Afterwards, he wrote to Secretary for Air Hugh Fraser, setting out his ideas for turning Blue Steel into a viable weapon. He wanted authority to fuel missiles at Readiness on aircraft, with warheads fitted. He wanted thermal batteries in Readiness weapons installed and left there, avoiding last-minute insertion. He even requested clearance to fly fuelled missiles, with warheads loaded, from main bases to dispersals, to test Blue Steel's ability to tolerate long periods of Readiness on dispersal airfields. He wrote again four months later, this time to the Vice-Chief of the Air Staff (VCAS), Air Chief Marshal Sir Wallace Kyle, complaining that no decision had been taken on his recommendations, especially regarding batteries and fuelled/armed missiles on QRA.[61]

Blue Steel crews were not envied by freefall aircrew, including Rob Williams, a Vulcan Captain on IX Squadron: "On reflection, I am glad I wasn't posted to a Blue Steel squadron. The procedures that had to be followed with a 'wet' (fuelled) missile were an absolute nightmare. Blue Steel… in my view, was a dangerous weapon system."[62] Vulcan Captain John Huggins was no fan: "In my view, the stand-off bomb was useless. It was much better to be in a freefall crew. Blue Steel crews were very much a group apart."[63]

When the V-Force went low level, Blue Steel 1's already modest range was reduced very significantly, to just 35-50NM. This brought the carriers much closer to the outer ring of point defences around major targets (a parallel hazard to that faced by freefall aircraft, required to "pop-up" to 11,000 ft, inside the SAM kill zone, to drop Yellow Sun 2 around seven to eight miles from target). Both factors had a negative impact on V-Force operational effectiveness at low level. In 1967 freefall squadrons received WE.177B, a true low level weapon, but one that required direct overflight of the target!

[60] Wynn, *RAF nuclear deterrent forces*, 218-219.
[61] Ibid, 219-220.
[62] Rob Williams, Vulcan Co-Pilot, 12 Squadron; Captain, IX Squadron; amongst documents/text provided: 27/10/20.
[63] John Huggins, Vulcan Co-Pilot/First Pilot, 101 Squadron, RAF Waddington; Captain, 50 Squadron; amongst documents/text provided: 26/10/20.

The first Blue Steels had gone to 617 Squadron and, appropriately, a 617 Squadron Vulcan flew the last Blue Steel sortie, on December 21 1970.[64] Some Blue Steel Vulcans were then converted to the freefall role. Nuclear weapons historian Mike Fazackerley describes this as "extraordinary … it would have been the subject of public controversy, had it not been handled in such a low profile manner. The RAF managed this by emphasising the restoration of the Vulcan's conventional bombing role. There was no real discussion of its continued nuclear role post-Polaris."[65] Wittering's Victors were withdrawn in late 1968, for conversion to tankers.

The laydown bomb

WE.177B, a 450KT parachute-retarded laydown bomb, had to survive a landing after ultra low level release (as low as 100 ft or less) from a V-bomber flying at up to 415 kts directly over the target. The carrier would have barely one minute to escape. During an attack, of course, there were physical constraints. Vulcan Nav/Radar Roy Brocklebank makes the point that countervalue targets imply buildings, which would "predicate against ultra low level release."[66]

Laydown was a proven concept. American "E" weapons included the Mk.43 laydown bomb, carried by Valiants in the low level role since 1963. Following Skybolt's cancellation and the decision to switch the entire V-Force to low level, one priority was to replace the Yellow Sun 2 freefall bomb (requiring "pop-up" release) with a new laydown weapon dropped at ultra low level, under the main SAM screen. There was no inclination to turn to the readily available American Mk. 43, which was controlled under dual key.

The fully realised WE.177 had three variants: the WE.177B strategic weapon, the WE.177A low yield tactical weapon and the WE.177C high yield tactical weapon. WE.177 offered extraordinary flexibility. Mike Fazackerley notes that, unlike the mechanical arming and fuzing of Yellow Sun and Red Beard, WE.177 had electronic arming: "This made WE.177 a very flexible weapon." [67]

[64] Wynn, *RAF nuclear deterrent forces,* 461, 620.
[65] Mike Fazackerley, amongst documents/text provided: 15/11/20.
[66] Squadron Leader Roy Brocklebank, Vulcan Nav/Radar, 12 Squadron, RAF Coningsby/RAF Cottesmore; Wing Targeting Officer, RAF Waddington; email: 12/8/19.
[67] Mike Fazackerley, *Weapon X: the bomb with no name: A short history and technical description of WE.177* (unpublished), 128-146.

There were no arguments over the need for the strategic weapon. It avoided a climb into the SAM zone, as required by Yellow Sun 2. WE.177 also had a crucial advantage – it already existed as a project (albeit on slowburn until Skybolt was lost). This bomb was first conceived as a new tactical weapon, to replace Red Beard. It then became apparent that WE.177 could also meet the need for a high yield strategic laydown bomb and the way became clear for WE.177B, despite the fact that it was a freefall weapon.

Mike Fazackerley outlines the thinking of the time: "By the mid-1960s, a weapon requiring direct overflight of the target – even at ultra-low level – was not a good option. Rather, it would be best to describe the laydown bomb as the *best available option*. It was seen as faster and less risky to go ahead with WE.177 …"[68] Given the commitment to Polaris, any fresh RAF attempt to promote a long range air-delivered system would have been seen as an attempt to undermine that decision.

WE.177B entered service in late 1966. Its operational lifespan exceeded 30 years – it remained in the RAF armoury until March 1998. WE.177B was a remarkable engineering achievement; it contained less than 100 lbs of conventional explosive, as against the 5,543 lbs inside Blue Danube. The shock absorption solution (high density polyurethane foam) coped with impact velocities of up to 180ft/sec and deceleration forces of up to 2,000 G. The bomb was designed to "slap down" tail-first on laydown, with the tail cone taking the lateral shock. Four parachutes slowed the weapon to a delivery speed of 112 mph.[69] The weapon utilised the RE.179 fusion warhead intended for Skybolt.[70]

This compact bomb (133 in. long) weighed around 1,000 lb. Its fissile material was recovered from obsolete weapons. The tactical strike/naval variant, WE.177A, had a maximum yield of 10KT and was carried by the Vulcan B.2, Buccaneer, Jaguar and Tornado. WE.177C, another tactical weapon, had a much higher yield (190KT) – required to destroy airfields and other area counterforce targets too large for WE.177A. According to Chris Gibson, this utilised some warhead elements from ET.317, the British Polaris warhead, which became available during the "Chevaline" upgrade (replacing one of the missile's three warheads with penetration aids).[71] The

[68] Mike Fazackerley; documents/text provided: 15/11/20.
[69] Fazackerley, *Weapon X*, 118-126.
[70] Gibson, *Vulcan's hammer*, 53.
[71] Ibid.

RAF inventory included a peak of 207 WE.177 weapons of all variants.[72] The last examples of WE.177A were withdrawn in March 1998. The B and C variants were withdrawn in 1995. The WE.177C's yield was set at just below the 200KT limit applying to weapons allocated to SACEUR in the European Theatre. In 1962 this limit had been set at 10KT, explaining WE.177A's relatively low yield.[73]

In early 1964 the Government declared the V-Force fully operational for low level strike against the Soviet Union. This was an over-statement; the freefall V-bombers had to wait until late 1966 for WE.177B, a true low level weapon. Mike Fazackerley describes how the V-Force made the best of it: "In the meantime, they carried on with Yellow Sun 2 and this required a "pop-up" delivery. The idea of "popping-up" on the outskirts of Moscow says it all! The reason for the long wait had a lot to do with the weapon's sheer complexity – there were only one or two avoidable delays. In total, WE.177B was around six months late … but the wait would have been just as long for Skybolt."[74]

Following Skybolt's cancellation, the Polaris deal and the subsequent grounding of the Valiants, the "Interim Plan for the V-Force" (until Polaris handover) provided for 88 aircraft (11 squadrons).[75] This consisted of 40 Blue Steel-armed aircraft (three Vulcan and two Victor squadrons), together with 48 freefall Vulcans armed with WE.177B. The Victor was less suited to low level operations and the requirement for it to carry WE.177B was withdrawn. The Vulcan freefall force received 53 WE.177Bs (one bomb for each aircraft, plus five operational spares – allowing for maintenance rotation at the Atomic Weapons Research Establishment (AWRE). Following Blue Steel's retirement and the conversion of some carrier aircraft to freefall bombers post Polaris handover, there were not enough high yield WE.177Bs to arm the enlarged freefall V-Force (56 aircraft, 53 WE.177Bs), but other weapon variants were available. In Cyprus, for example, several low yield WE.177As were held.[76]

The Polaris handover was not the end of the RAF's nuclear role. Indeed, the operational lifespan of the nuclear-armed V-Force post-Polaris handover (1969-82) closely matched the frontline strategic lifespan (1957-69). The V-Force continued as

[72] Norris and Kristensen, "The British nuclear stockpile", 69-75.
[73] Mike Fazackerley; documents/text provided: 15/11/20.
[74] Ibid.
[75] Wynn, *RAF nuclear deterrent forces*, 423.
[76] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; documents/text provided: 25/6/20.

an element of NATO's deterrent.[77] Most aircraft remained with Strike Command in the UK, although two squadrons (IX and 35) moved to Cyprus, to succeed Red Beard-armed Canberras. Their main war mission was to strike the USSR via the southern route.[78] These Vulcans returned to the UK following the 1974 Turkish invasion of Cyprus.

In 1976 there remained 48 WE.177B-armed Vulcans (44, 50, 101, IX, 617 and 35 squadrons), based at Waddington and Scampton and reducing to five squadrons by 1982. It is unclear exactly how WE.177 rounds were distributed post V-Force. When the Vulcans retired in 1982, WE.177B rounds went to the Tornado force. Meanwhile, some A rounds were converted to C. According to Mike Fazackerley, the most likely distribution was: Buccaneer strike, A and C; Buccaneer maritime strike, A; Jaguar, A and C; Tornado strike, B and C; and Tornado maritime strike, A.[79]

This chapter identifies a series of factors influencing V-Force operational effectiveness during the six-year wait for Polaris. The most significant issue is the missile threat – MBF exposure to destruction on the ground. The second major issue is vulnerability in the air: the growing capability of Soviet air defences. These exposures have a relationship with V-Force weapons. Exposure on the ground was aggravated by slow generation and lack of reliability surrounding Blue Steel. The powered bomb's short range was further reduced by low level launch, requiring the carriers to get closer to point defences. As for freefall weapons, Yellow Sun 2 required an 11,000ft "pop-up" into the SAM threat zone – a fundamental incompatibility with low level strike. WE.177B, its successor, was another freefall weapon and required direct overflight of the target. Its service on the strategic frontline lasted barely three years (although the weapon remained in the RAF armoury for over 30 years).

[77] Wynn, *RAF nuclear deterrent forces,* 553.
[78] Ibid, 546.
[79] Mike Fazackerley, *Weapon X*, 106-107.

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THE MBF MISSION

This chapter presents an overview of V-Force development: frontline strength, the evolution of the operational role, the emphasis on crew quality and continuity and the early vision of Mk.2 Vulcans and Victors armed with second generation, long-range stand-off weapons. Key issues are introduced, including MBF dispersal and other measures to reduce exposure on the ground, together with the framework for operational control, including delegated powers to launch retaliation and "positive control" of V-bombers in the air. There is also an overview of the complex issues surrounding targeting and the adoption of a "wartime" state of alert and readiness, in response to the missile threat. The transition from high altitude attack to low level strike is another significant theme.

Building the V-Force

In 1957 V-Force expansion gathered pace. By the year's end there were seven Valiant bomber squadrons, a Valiant photo-reconnaissance squadron, a Valiant ECM squadron and two Vulcan B.1 squadrons.[1] Yet there was continuous pressure to cut V-Force size. An early 1957 paper to the Cabinet envisaged a V-Force of 184 bombers: 120 Mk. 2 Vulcans and Victors (for deep penetration targets), 40 Mk. 1 Vulcans and Victors (to attack "fringe" targets) and 24 Valiants – eventually SACEUR's TBF.[2]

Growing concern over the war-fighting capabilities of subsonic bombers in the missile age was exceeded only by worries about defending this V-Force profile in London; politicians, senior civil servants and rival services pressed for a reduction in force size. Matters came to a head on August 2 1957, when a smaller V-Force frontline of 144 aircraft was agreed, including 104 of the more powerful Mk. 2 Victors and Vulcans. This was seen as the "appropriate compromise" between military and economic considerations. One year on, however, Secretary for Air George Ward found it necessary to write to the Defence Board, defending the V-Force at 144 aircraft. He

[1] Wynn, *RAF nuclear deterrent forces*, 323.
[2] Ibid, 155.

reminded them of the decision of August 1957, accepting 144 aircraft. He also pointed out that just three months previously (on July 16 1958), the Prime Minister had reaffirmed the purpose of the UK's independent nuclear capability:

- "To retain our special relation with the United States and, through it, our influence in world affairs and, especially, our right to have a voice in the final issue of peace or war.
- "To make a definite, though limited, contribution to the total nuclear strength of the West – while recognising that the United States must continue to play the major part in maintaining the balance of nuclear power.
- "To enable us, by threatening to use our independent nuclear power, to secure United States cooperation in a situation in which their interests were less immediately threatened than our own.
- "To make sure that, in a nuclear war, sufficient attention is given to certain Soviet targets which are of greater importance to us than to the United States."[3]

Ward moved to his main task – defence of the 144-strong V-bomber force: "To constitute a minimum deterrent and serve the purposes for which it is intended, the V-Force must be operationally viable, i.e. it must be sufficiently large and well-equipped to deliver enough bombs to inflict an adequate measure of destruction in Russia."[4]

Ward argued that all Mk. 2 Victors and Vulcans should be armed with powered bombs but, subsequently, cancellation of Blue Steel 2 (January 1960) and Skybolt (December 1962) denied the V-Force second generation stand-off weapons. In 1958, however, these matters were undecided and OR. 1159, for long range Blue Steel, had been issued only a few months previously. Ward pressed his point. "The Defence Committee had decided a year ago to maintain the Mk. 2 element of the V-Force at a high level because these aircraft were required to carry first the short range and then the long range powered bombs". These weapons were required to "maintain the capacity of the V-Force to attack deep penetration targets in spite of the expected development of the Russian Surface-to-Air Guided Weapon (SAGW) defences". There was no change in this requirement.[5] In fact, this requirement *did* change, within a few years, leaving over half the V-Force as freefall bombers.

[3] Ibid, 323-325, citing DEFE 25/18, "The V-bomber force and the powered bomb", memorandum from Secretary of State for Air George Ward to the Defence Board, October 29 1958 (DB (58) 10).
[4] Ibid.
[5] Ibid.

Ward made it clear that "retaliation", in the late 1950s, involved a long list of city targets:

> Operational studies suggest that the force at present planned, after allowing for unserviceability and losses, could deliver successfully attacks on 30 to 40 out of 131 major centres of Russian industry and administration with a population of more than 100,000. The larger and more important targets would need more than one bomber to destroy them and the number of targets is progressively increasing … Any reduction in the size of the force would more than proportionately reduce the number of targets that could be attacked. In the first place, a smaller force would still have to attack the large and more important targets which require more than one bomb. For example, a 25% reduction could halve the number of targets. Secondly, reduction in the size of the attacking force would increase disproportionately the effectiveness of the fighter defences and prevent a larger number of bombers from reaching their targets… the real possibility must be faced that any further reduction in the size of the bomber force would so reduce its effectiveness that no significant proportion would survive to deliver its bombs on target.[6]

This was dangerous territory, given the fundamental question. In the event of a pre-emptive missile strike, could V-bombers escape in sufficient numbers to destroy major Soviet targets? In March 1955 Air Marshal Sir George Mills, then AOC-in-C Bomber Command, reported on V-Force progress to the CAS. Whilst there would be reasonable warning of incoming Soviet bomber attack, Mills fretted over the vulnerability of his fledgling force: "… we can never be a true deterrent force until we can really disperse." His worries were shared. The VCAS put his concerns on paper: "… the V-bomber force is being built up primarily as a deterrent and one of the main objects of the deployment plan is to ensure that the enemy realises that the force cannot be wiped out by 10 bombs on 10 Class I airfields."[7]

The Valiant force reached full strength in May 1957, with 59 aircraft (seven squadrons). The first Vulcan squadrons formed and the Victor arrived at 232 Operational Conversion Unit (OCU). The first Victor squadron began receiving aircraft in April 1958. The upgrade of Victors and Vulcans to Mk. 1A standard began in 1959, these variants having more powerful engines and improved ECM.[8] The importance of crew continuity was recognised early on. In November 1954 the VCAS made this point: "Stability of aircrew postings is essential if the MBF is to become really

[6] DEFE 25/18, "The V-bomber force and the powered bomb," Annex B.
[7] Wynn, *RAF nuclear deterrent forces*, 79-80.
[8] Ibid, 144-151.

efficient."[9] Long flying tours were deemed necessary – 5¼ and 7½ years, depending on seniority. This would ease the costly training commitment and raise standards overall. There were unfortunate repercussions, however, in future years. Young aircrew seeking sun and adventure were not best pleased at the prospect of spending long years on bases in eastern England; they would come to resent being "locked in".

Gathering strength

By early 1960 Bomber Command had six squadrons of Valiant B.1s (54 aircraft), three squadrons of Victor B.1s (24) and three squadrons of Vulcan B.1s (24) – 102 aircraft.[10] By late 1962 the V-Force was transformed, with 15 main force squadrons: 120 aircraft – six squadrons of Vulcan B.1/B.1As and three of B.2s (72 aircraft) and four squadrons of Victor B.1/B.1As and two of B.2s (48)[11]. In addition, three squadrons of Valiants (24 aircraft) formed SACEUR's TBF, based at Marham. There were also Thor IRBMs – 15 squadrons (45 missiles) in 1960, rising to 20 squadrons (60 missiles) by 1962.

In February 1962 Bomber Command listed 36 MBF airfields:

- Class I (main bases with ORPs and facilities for four aircraft): Finningley, Coningsby, Honington, Scampton, Wittering, Cottesmore, Waddington, Gaydon and Wyton.
- Dispersal airfields with ORPs and facilities for four aircraft: Burtonwood, Bedford, St. Mawgan, Ballykelly and Kinloss.
- Dispersal airfields with ORPs and facilities for two aircraft: Filton, Leconfield, Leuchars, Lossiemouth, Boscombe Down, Pershore, Cranwell, Middleton St. George, Yeovilton, Leeming, Llanbedr, Coltishall, Valley, Manston, Brawdy, Lyneham, Wattisham, Stansted, Elvington, Prestwick, Machrihanish and Bruntingthorpe.[12]

As for the Thors, there was a view in some quarters that they were not fully part of the British deterrent, being under dual control. On paper, the 60 Thors in Britain, with megaton warheads and a range of 1,500 miles, were a formidable force. Yet, they were vulnerable, being liquid-fuelled and above ground.[13] Macmillan supported the

[9] AVIA 65/43, "The development of the MBF: the place of the MBF in British strategy", note by VCAS, November 2 1954.
[10] DEFE 25/18, "Bomber Command", note, January 4 1960.
[11] *Wikipedia,* 2021, "V bomber". Last modified June 22 2021, https://en.wikipedia.org/wiki/V_bomber
[12] Wynn, *RAF nuclear deterrent forces,* 306-307.
[13] Ibid, 344-345.

UK Thor force as it demonstrated Anglo-American nuclear cooperation.[14] There were other views. Air Chief Marshal Sir Harry Broadhurst, when AOC-in-C Bomber Command, described Thor as "a weapon of doubtful operational value which, in any case, can never be used until deterrent policy has failed …"[15]

The V-Force peaks

V-Force strength peaked in 1964, with over 180 aircraft, including the Valiants (withdrawn the following year due to airframe fatigue). By 1968 the force was much reduced; Victors were converted to tankers, succeeding the tanker Valiants by mid-1966.[16]

Nav/Radar Roy Brocklebank described the V-Force at peak: No. 1 Group Wings were equipped with the Vulcan and No. 3 Group Wings had Valiants and Victors. The main force in No. 1 Group was deployed in three Wings, each with three squadrons of eight aircraft. The Scampton Wing was equipped with Blue Steel. The Waddington and Coningsby Wings were equipped with freefall weapons. No. 3 Group Victors were deployed in three wings, but with only two squadrons of eight aircraft each. Victor Mk. 1 aircraft were deployed at Honington and Cottesmore and the Mk. 2, armed with Blue Steel, was at Wittering. The Valiant, by 1964, was deployed at Gaydon (the OCU), Marham (main force) and Wyton, with the Photo Reconnaissance (PR) version.[17]

The Vulcan B.2 first appeared at 230 OCU in July 1960. Its arrival may explain why aircrew detected no erosion of V-Force capability. Certainly, Air Vice-Marshal Michael Robinson noticed no fall in capability: "We who were in the V-Force in the early 1960s, with our improved Mk.2 versions of the Vulcan and Victor, were not aware of any decline. The pattern of QRA commitments, frequent no-notice alert exercises and the demanding training schedules kept us all very much on our toes."[18] Victor Captain Jeremy Mudford was impressed by the upgraded aircraft: "…the total power available rose from 44,000 lbs to 80,000 lbs. The take-off performance of the Victor B.2 was

[14] John Boyes, "The Thor IRBM – the Cuban Missile Crisis and the subsequent rundown of the Thor force", RAF Historical Society, *Journal 42* (2008): 40-56.
[15] AIR 20/10325, letter to VCAS, March 10 1959.
[16] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter, amongst documents/text provided: 25/6/20.
[17] Ibid; *Flypast*, October 17 2008, based on a lecture to the Royal Institute of Navigation's History of Air Navigation Group, Tangmere.
[18] Stoddart, *Losing an empire and finding a role*, 83.

quite extraordinary."[19] The Mk.2's greater operating height, however, lost significance when the V-Force went low level, but, to some degree, increased range allowed for better target coverage and more opportunities for indirect routeing.[20]

Had Skybolt gone into production, Vulcan B.2s would have carried two each.[21] With Polaris in prospect, however, decline set in. The MBF in January 1965 consisted of 104 aircraft (32 Victors and 72 Vulcans).[22] The decline progressed during 1965, with numbers falling to 88 aircraft (11 squadrons).

The AOC's Directive

Every incoming AOC-in-C Bomber Command received a Command Directive. In February 1965 Air Chief Marshal Sir Wallace Kyle became AOC-in-C, charged with ensuring the bulk of his force could survive a war scramble. He also received delegated powers to launch a retaliatory nuclear strike, on his own initiative, in the event of war and a total breakdown of communication between Bomber Command and Government.

Kyle's Directive recognised the real potential for a catastrophic communications collapse. On June 15 1960, an informal meeting of MoD, Air Ministry and Foreign Office representatives discussed procedures for launching retaliation. A recent exercise ("Halbert") had exposed the need for improved communications with the Prime Minister and Whitehall. The notes from the meeting state: "This was a matter partly of operational effectiveness and partly of the credibility of the deterrent." Ballistic Missile Early Warning System (BMEWS) Fylingdales would not be ready until 1963. Assuming, however, at least some degree of strategic warning, the core problem was reaching the Prime Minister whilst he was out of London. The meeting concluded that he should join the AA: "If his car were linked to the Automobile Association's radio network … messages could be passed to him *en clair* within a minute or so." The cost of the equipment for the car was around £200, plus £20 annual rental.[23]

[19] Jeremy Mudford, Victor Captain, 57 Squadron, RAF Honington; 139 Squadron, RAF Wittering; interviewed: 8/2/18.
[20] AIR 41/85, "The RAF in the postwar years: The bomber role 1945-70" (1984), Humphrey Wynn, Air Historical Branch (RAF), 89.
[21] Wynn, *RAF nuclear deterrent forces*, 314.
[22] DEFE 13/849, note from F. Cooper, January 22 1965.
[23] CAB 21/4756, "Procedure for launching nuclear retaliation", informal meeting, Cabinet Office, June 15 1960.

The June 1960 meeting confronted the worst case: total communications breakdown between Bomber Command and Government. It concluded that, in the absence of political instructions at the time of breakdown, AOC-in-C Bomber Command should have discretion to launch the V-Force under "Positive Control" – a system under which the bombers are required to turn back on reaching the 8 deg. East "Go/No Go" line in the absence of an authenticated "POSREL" (Positive Release) message. AOC-in-C would have full responsibility for launching a retaliatory strike if, "despite all efforts by all reasonable means", he was unable to communicate with Government and an enemy nuclear attack had occurred. There was no specified waiting time before discretion could be exercised.[24] Missile launch, of course, was an irrevocable act but, with the withdrawal of Thor, delegated powers became entirely concerned with British nuclear forces under Positive Control, so allowing more time to achieve contact with political authority.

There was a view that Soviet appreciation of delegation of command authority to the military would both lessen the incentive to mount a decapitation attack "and increase the credibility of deterrence."[25]

Had an authenticated "POSREL" signal been sent, surviving V-bombers would have crossed the Go/No Go line and pressed home a retaliatory strike. The Positive Control line emerged in late 1957/early 1958.[26] It was defined in a note attached to a letter from the Air Ministry to the Cabinet Office (July 9 1959). It was not a fixed line of longitude but, rather, a contour line running over friendly territory (Norway) and international waters. Flight time to the Positive Control line was around 40 minutes. Each bomber would maintain a listening watch; if no authenticated orders to proceed with the attack were received by the time it reached the Positive Control line, it automatically returned to base. Similar procedures applied to SACEUR-assigned TBF Valiants.[27]

Consultation *in extremis*

At the brink of nuclear war there would be little time for discussion between Prime Minister and President. London made efforts to prepare for this situation, by

[24] Ibid.
[25] Twigge and Scott, *Planning Armageddon*, 87-89.
[26] CAB 21/4757, Annex A, "Launching of strategic nuclear reprisal", minute by J.M. Wilson, February 3 1958.
[27] CAB 21/4756, "Nuclear retaliation procedures", letter from F. Cooper, Air Ministry, to J.S. Orme, Cabinet Office, July 9 1959; note: "Procedures for authorising nuclear retaliation, RAF Bomber Command," attached to letter.

simplifying the process and reserving the decision to launch a nuclear attack to the last possible moment. In early 1962 the issues were set out in a draft memorandum, for discussion with the Americans. Consultation in extreme emergency would focus, obviously, on the release of strategic nuclear forces. The Prime Minister would have to approve use of SAC forces based in Britain and Polaris submarines at Holy Loch. Other subjects included the release of US warheads to British nuclear forces, the use of tactical nuclear forces under NATO command and, potentially, the use of nuclear weapons beyond the NATO area. The draft document reflected on the challenge: "This constitutes a considerable agenda and will take a considerable time to get through. It would clearly be impossible to complete it in a single conversation in circumstances of emergency." Simplification meant isolating those measures which did not, in themselves, commit nuclear forces. These could be agreed and authorised separately, in advance of an attack.[28] This memorandum was polished and re-polished; six months later it had still to be presented to the Americans.

How important were British strategic nuclear forces to the Americans? There was a British view that, taken overall, the Americans did not approve of independent nuclear forces, yet the fact remains that the US Government and military did a great deal, over many decades, to support the British independent (or, rather, inter-dependent) deterrent. The V-Force complicated Soviet calculations of Western capabilities and intentions, with the UK a distinct "second centre" of nuclear decision-making. There were also operational considerations which, at least in the early years before the American Inter-Continental Ballistic Missile (ICBM) force matured, served to magnify the significance of Britain's relatively small retaliatory force, from an American perspective. Given the comparatively short war flights of the V-bombers, together with the 60 Thor missiles, other dual key nuclear assets (and US nuclear systems based in Britain), the UK occupied a significant frontline position.

Delivering the mission

V-Force retaliation was planned to the last detail, with a large measure of ingenuity and some ruthlessness. "Plan A" V-Force targets were SACEUR (NATO) targets, for the most part "counterforce" military assets, but often located in and around the big cities. "Plan B" targets were National, identified as "countervalue" – the big cities themselves. The Plan A NATO target list was the Allied war-fighting programme (the

[28] CAB 21/4840, "Nuclear retaliation consultative procedures," draft memorandum for discussion with the US Government, January 18 1962.

Single Integrated Operations Plan, or SIOP), with the V-Force contributing to an all-out retaliatory attack by the West, whilst the Plan B (National) target list was an expression of "pure" deterrence: helping to keep the peace by projecting the maximum countervalue threat from Britain's limited nuclear stockpile. Everyone struggled to visualise a situation in which the UK *would* wage nuclear warfare without its NATO allies but the most important fact was that it *could.* Each V-Force target was assigned one or more "Accounting Line Numbers" (ALNs), a phrase deliberately selected for lack of meaning. Important targets would receive multiple strikes. Crews were prohibited from discussing their targets with other crews. They might well have the same target, with minimum time separation between nuclear bursts. Each crew, in the low level era, would fight World War 3 alone. Their sole objective was to reach and destroy the target. They trained to attack a National target and two NATO targets – a primary and a secondary. SACEUR targets had ALNs in the 100, 200 and 300 series. National targets had ALNs in the 400 and 500 series. [29] National targets included the obvious, such as Moscow, Leningrad, Kiev and Minsk.

An October 1958 Air Ministry note to MoD considered the sensitive issue of how many V-bombers might reach their targets. The driver behind this note was fear of a further cut in V-Force size and the consequences for operational effectiveness. This rather naïve note sets out three factors governing the number of bombers reaching their targets: the number of frontline bombers, the number taking off after allowing for unserviceability and, finally, percentage losses *en route:*

> The percentage losses *en route* will depend on the strength and effectiveness of the enemy fighter defences. They will also vary between Mk. 1 and Mk. 2 V-bombers. Current operational studies suggest that, allowing for 25% unserviceability, a bomber force of 104 Mk. 2 and 40 Mk. 1 Victors and Vulcans could effectively deliver about 50-60 bombs in the vital first strike. This would imply successful attacks on about 30-40 out of 131 big centres of Russian industry and administration with a population exceeding 100,000. More than one bomb must be delivered against the larger and more important targets.[30]

This note (with figures cited by Secretary for Air George Ward) is naïve in that it takes account of unserviceability but makes no specific allowance (perhaps understandably) for the likely large-scale destruction of the force on the ground in a ballistic missile strike – an obvious prospect by late 1958.

[29] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.
[30] DEFE 25/18, "The number of V-bomber aircraft which will reach their targets," note from Air Ministry to MoD, October 10, 1958.

The key issue was to avoid being caught on the ground. This required Bomber Command to behave more like Fighter Command, with a total focus on operational readiness. Training, exercises, maintenance and duty periods became dominated by the need to generate aircraft within specified time periods and get the aircraft off the ground quickly, so allowing some to survive an attack and continue on, to deliver retaliation. The eventual result was QRA, an unprecedented peacetime state of readiness for war persisting until the Polaris handover in 1969 (with many elements continuing on into the 1970s and beyond – to the present day, in a limited sense). On May 20 1959 Sir Kenneth Cross became AOC-in-C Bomber Command. The central V-Force requirement – 75% of aircraft at Readiness, armed and dispersed within 24 hours – had been in place for nearly a year and its attainment proved difficult. A few weeks after assuming command, Cross wrote to the VCAS, Air Marshal Sir Edmund Hudleston, stating that he had just one squadron able to meet the July 7 1958 Readiness requirement, but promising six more by year-end and a further five by April 1960.[31]

Cross applied pressure and work accelerated on measures to improve MBF response times. Trials were organised to determine minimum take-off time for a dispersed flight of V-bombers (elapsed time, from scramble order to wheels up, for the first and last aircraft).[32] There was a complete change of mood on MBF stations – a new "frontline feel", with the continuous presence of sufficient personnel to bring a high proportion of aircraft to Readiness within 24 hours, 365 days of the year.

Timely dispersal was critical. By late 1959 16 airfields were ready for MBF use; a further eight were in an advanced stage of planning and due to be ready during 1960. Another six awaited Treasury approval.[33] In June 1961 CAS accepted a reduction in planned ORPs from 120 to a more realistic 100 (14 x four aircraft; 10 x two aircraft – but with potential to expand to four in future; and 12 x two aircraft).[34] One major problem was the inability to disperse aircraft armed with dual control American weapons under "Project E". This concentrated the three TBF Valiant squadrons at Marham, their main base, exposing them to wholesale destruction.

[31] Wynn, *RAF nuclear deterrent forces*, 300-302.
[32] Ibid.
[33] Ibid, 303.
[34] AIR 20/11448, "Bomber dispersals", June 6 1961.

By early 1960 the AOC-in-C told the Air Ministry that his Command met the 75%/24 hours requirement during weekdays, then adding: "In order to achieve a Readiness capability over weekends and public holidays, 25% of the available aircraft are held at two hours' Readiness during these periods …" The pace was hotting up. This report was made after MoD had called for six-monthly updates on V-Force Readiness, commencing January 1960.[35] Overhanging everything was the threat of a Soviet missile strike and a warning time (given an operational BMEWS) that could be less than four minutes – so allowing only a proportion of aircraft at advanced cockpit readiness a chance to get off. One outcome of growing concern about vulnerability on the ground was "Micky Finn" – an alert and dispersal exercise introduced in late 1960. "Exercise Mick" required generation at no notice but stopped short of dispersal. "Exercise Mayflight" embraced all aspects of Readiness and dispersal, including the scramble, but on a notice basis. Micky Finn was very different – a force war exercise that could be called, at no notice, on a weekday or weekend.[36]

There were also Group exercises ("Groupex"), Command exercises (eg. "Exercise Yeoman", a major UK air defence exercise) and NATO exercises. There were training sorties – "profiles" (long cross-country flights with built-in exercises and simulated emergencies) and "Compex" (preparation for Command bombing and navigation competitions). In addition, single bombers flew "Western Ranger" flights to Canada and the USA and "Lone Ranger" flights east. Squadron-based dispersal was practised in "Kinsman" drills – normally involving the dispersal of two or four aircraft.[37]

Barriers to mission delivery

Bombers are vulnerable on the ground and in the air and these exposures intensified from 1960 onwards. In its important "interim report" of late 1959, the British Nuclear Deterrent Study Group (BNDSG) concluded that Blue Steel 1-armed bombers would become increasingly ineffective after 1965 and that Blue Steel 2 would only extend V-Force life by two or three years after 1965. It warned that, *irrespective of weapons carried*, the V-Force would remain vulnerable to pre-emptive attack on its bases. In a rather limp concluding comment, it could only suggest that "some of the bombers would probably be able to escape."[38]

[35] Minute, DCAS/VCAS, July 30 1959 (RWM/889, in 90/18, "Operational readiness of the RAF").
[36] Wynn, *RAF nuclear deterrent forces*, 304-306.
[37] Ibid.
[38] AIR 14/86, "The RAF in the postwar years: Defence policy and the Royal Air Force 1956-63", T.C.G. James, Air Historical Branch (RAF) (1987), 237, 241.

Much effort went into reducing MBF vulnerabilities. Inevitably, the early focus was on penetrating Soviet defences, rather than avoiding destruction on the ground, as the main threat to V-Force bases at that time was from Soviet bombers. When the Soviet missile threat became dominant, however, vulnerability on the ground received greater attention. The Joint Intelligence Committee (JIC) eventually assumed that the Soviets would allocate two 500KT missiles and two 1MT aircraft-delivered weapons to each MBF airfield.[39] There was no questioning the fact that V-bombers must be capable of dispersing rapidly. Translating this into criteria applicable to dispersal airfields, selecting those airfields and providing facilities to meet the criteria were formidable and expensive tasks; much time and effort was devoted to it, with the Treasury needing to be convinced, every step of the way, that these measures amounted to adequate insurance and no more.[40] A central question (largely, but not entirely, financial in nature) was how far precautionary measures could go in the interests of effective deterrence without running into the objection that the aim was to *avoid war, not fight it*. In 1955 the Air Council agreed to a force of 240 V-bombers, dispersed over 10 Class I airfields and 45 other UK airfields (subject to review for factors including ultimate force size).[41] Revision on the latter grounds was required. In late 1957, following agreement for a V-Force of 144 bombers, the revised plan was based on no more than four aircraft per dispersal site, on a total of 26 airfields, with a full squadron (eight aircraft) remaining on each of seven Class I main bases. Later, extra dispersal airfields were added, as approved by the Minister of Defence, to ensure only four aircraft remained on each main base, should dispersal be ordered.[42]

Measures reducing vulnerability on the ground focused on the extremely short warning likely in a pre-emptive missile strike. Scrambling the entire V-Force required verified warning. Bombers can be recalled, but launching the entire V-Force before confirmation that missiles were actually incoming would expose aircraft to destruction as they were restored to Readiness upon return. Measures taken to ensure a proportion of the force would survive pre-emptive strike included elaborate dispersal arrangements and QRA, with part of the force always fully fuelled, armed and held at RS15.

[39] Peter Hennessy, *The Secret State,* Second Edition (London: Penguin, 2010), 211-212, referring to Annex A, COS 1929/2/11/67.
[40] AIR 14/86, James, "The RAF in the postwar years", 104-105.
[41] AIR 20/9729, "Deployment of the V-bomber force – Phase 1" (Air Council, A.C. (56)), note by AMSO, undated (probably Spring 1956).
[42] AIR 20/10530, "Readiness of Bomber Command", outcome of a meeting of, *inter alia*, CAS and the AOC-in-C Bomber Command with the Minister of Defence, July 24 1958.

The response to vulnerabilities in the air focused on ECM. In the early years "mutual support" barrage jamming was seen as the key to high altitude penetration, but this changed following the loss of Gary Powers' U.2 to a Soviet SAM on May 1 1960. The U.2 was brought down whilst flying well above the V-bombers' maximum ceiling. New and radical measures to improve operational effectiveness were required when it became clear by late 1962, with Skybolt's cancellation, that the V-bombers would not receive an advanced, long range weapon allowing them to attack from outside heavily defended airspace. During the 1960s – and for over a decade thereafter – the V-Force soldiered on with freefall weapons and, until the late 1960s, Blue Steel 1, with its very short range and other inadequacies. The only option for continued credibility was to switch from high level attack to low level nuclear strike.

Going low

The advantages of low altitude attack were acknowledged over 10 years before the entire V-Force went low level following Skybolt's cancellation. The Air Staff first considered the need for a "Low Altitude Bomber" (LAB) in June 1951, two and a half years before the first Valiant flew. LAB, a high speed, low altitude bomber to supplement the V-bombers, recognised elementary military logic. The V-bombers operated at 40,000ft plus, but, as Tony Buttler (2003) observed, this cast away the full three-dimensional advantage traditionally available to bombers. The Soviets could focus on the narrow, 40,000ft plus height band, where the V-bombers would become increasingly exposed to SAMs. LAB, however, would force the enemy to spread the defence effort and so ease pressure on the V-bombers.[43]

LAB's Operational Requirement (OR. 324) emerged in October 1953, with a war sortie profile of 500ft or less for 80% of the outbound leg and Mach 0.95 for 10 minutes over the target. The weapon was to be an air-to-surface missile. OR. 324, however, was cancelled within the year on grounds of cost and the many technological problems associated with low level penetration.[44] Yet, LAB was a timely reminder of the benefits of going low and this fostered early exploration of V-bomber low level capabilities.

Valiant low level trials, beginning in early 1956, exposed the severity of reduced fatigue life. In any event, these trials were suspended following a decision to focus on

[43] Tony Buttler, *British secret projects: jet bombers since 1949* (Hinckley (UK): Midland Publishing (Ian Allan), 2003), 54.
[44] Ibid, 55, 61.

preparing the new V-bombers for their primary high level strategic role. Nevertheless, the Valiant's capability to fly a low level bombing mission had been demonstrated and this was encouraging. In mid-1956, the Director of Operations (Bomber and Reconnaissance) sent a note to the Assistant Chief of the Air Staff, Operations (ACAS, Ops.): "… it would probably strengthen Russian convictions that they should build up their defences to counter a low level threat if they heard of us training in low level as well."[45] Such "signalling" of V-Force low level capabilities, if successful, might have had most unfortunate repercussions seven years later, when the decision was taken to give the entire V-Force an exclusively low-level strategic war role.

In the early 1960s further trials were held to test V-Force ability to find and accurately bomb targets at low level. Trial No. 407 examined the challenges of low level navigation. This employed a Valiant flying low level over Goose Bay, Labrador, across terrain closely mirroring what would be encountered on a war sortie.[46] This trial, ordered in August 1961, found that the Navigation and Bombing System (NBS) "functioned extremely well" but had "very restricted" range at low level – "even prominent features often could not be identified at ranges exceeding about 5NM".[47] Another observation was more discouraging: "Each low level sortie produces a certain amount of airframe damage, broken end-cleats and loose rivets, etc, which must be repaired before the next flight."[48]

No defensive armament

V-bombers had no defensive armament. Air Vice-Marshal Stewart Menaul (1980) described this as "perhaps the most difficult problem and certainly the most controversial … the RAF believed that the speed and height characteristics likely to be available in their new jet bombers, coupled with an elaborate array of equipment to provide extensive jamming and deception tactics *en route* to the target, would guarantee a reasonable degree of safety for the bombers."[49]

[45] AIR 2/14578, "Valiant in the low level altitude bombing role", D.Ops. (B&R), Air Commodore B.K. Burnett, loose minute to ACAS (Ops.), June 27 1956.
[46] AIR 2/14578, "Bomber Command Trial No. 407 – low level navigation of 'V' aircraft", letter from Squadron Leader A.D. Gibson, on behalf of the AOC-in-C Bomber Command, to the Under Secretary of State, Air Ministry (D.D. Ops. (B)), October 25 1961, appended to BC/S.96737.
[47] AIR 2/14578, "Trial No. 407, low level navigation in 'V' aircraft" (preliminary report), Bomber Command Development Unit, Report No. 12/61, October 3 1961.
[48] AIR 2/14578, "Bomber Command Trial No. 407 – low level navigation of 'V' aircraft", note on servicing personnel required for outstanding Valiant low level flights in the Trial No.407 programme, October 25 1961, appended to BC/S.96737.
[49] Menaul, *Countdown*, 48-49.

Bomber Command fought a long ECM battle with the Germans in World War 2. Menaul saw Britain as an ECM pioneer, but electronic warfare had been much neglected in the immediate post-war period.[50] The V-bombers' arrival triggered a revival but the first of the three types, the Valiant, had very little ECM. Wing Commander Peter West, a Valiant AEO, was unimpressed: "The Valiant's ECM was laughable … just terrible. In fact, we had better ECM during World War 2. The Valiant's tail warner was useless."[51]

Menaul preferred to focus on Russian difficulties and geographical issues favouring the MBF:

> Looking at a map of Russia, it is evident that the Soviets face an enormous air defence problem. The frontier from Murmansk in the north to Odessa in the south is 1,350 miles. In the late fifties, it could be penetrated at almost any point by V-bombers with a high degree of safety…From 1953 onwards, a concerted effort was made to update ECM doctrine, devise new designs and forecast likely developments in defence systems several years ahead, so that countermeasures could be ready … By 1954, the many and varied components of the nuclear deterrent force were in production, including aircraft, weapons, a wide range of complicated radio and radar equipment, bombing and navigational aids and ECM devices.[52]

The reality was not so rosy! Production delays involved vital items, from ECM to the NBS. In early 1955 the VCAS lost patience and issued a reminder that the Chief of the Defence Staff (CDS) saw the MBF as the "primary weapon in the national armoury."[53] The bombers were to have radar and fighter control communications jammers, a passive warning receiver and the Red Steer tail-warner. The Mk. 1A and Mk. 2 ECM outfit consisted of the Green Palm voice communications jammer, two Blue Diver metric jammers for use against ground radars, three Red Shrimps (S-band barrage jammers), Blue Saga passive warning receivers, the Red Steer tail-warner and "Window" (chaff) dispensers, at an estimated cost of £1 million per squadron. A 1963 report from the Air Ministry Electronic Warfare Committee noted that, four years previously, it had been decided that ECM policy long term would focus on noise jamming. The problem here was the absence of a "long term" environment – the goalposts were forever on the move. In October 1961 there had been a revised ECM programme for aircraft earmarked for Skybolt (and, therefore, not required to

[50] Ibid, 50.
[51] Wing Commander Peter West, MBE, Valiant/Vulcan AEO, 214, 138,12, 44 and 27 squadrons; interviewed: 30/4/19.
[52] Menaul, *Countdown*, 50-51.
[53] Wynn, *RAF nuclear deterrent forces,* 74.

penetrate Soviet defences). With Skybolt cancelled and the switch to low level attack in early 1963, a new ECM policy was approved in March. The situation was reviewed again that October, in the case of B.2 aircraft in the low level role, with some variation between freefall and Blue Steel aircraft.[54] By that stage, most existing ECM was irrelevant at low level. Vulcan Pilot Peter Moore (email: 18/3/21) described the tactics: "…the general plan was to fly high level to the edge of the enemy radar cover. Having detected radar pick-up, we would descend, aiming to edge the lobe but not be fully detected…At low level we kept our passive warners on, ready to employ counters when necessary. In my time we had a new Radar Warning Receiver (RWR) fitted. Active ECM was only employed once we sensed detection."

At Readiness

In July 1958 Bomber Command received its Readiness requirements, to be met 24/7, 365 days a year; these were later confirmed at a meeting between the Minister of Defence and the Secretary of State for Air:

- Strategic warning: after 24 hours' strategic warning "75% of the MBF should be at Readiness, armed and dispersed."
- Tactical warning: "a Readiness of 40 minutes should be capable of being sustained for up to one month and/or 15 minutes for one week."[55]

There were incremental requirements for generation: "After strategic warning medium bomber aircraft should become available as follows: 20% in two hours, 40% in four hours, 60% in eight hours and 75% in 24 hours." During 1959 Bomber Command worked hard to meet these targets but still had some way to go.[56]

The missile threat had put growing pressure on what remained of Bomber Command's "old ways" – including acceptance of reduced Readiness at weekends and during public holidays. One problem was the time required to recall personnel. This had prompted the decision to retain 25% of the Command at Readiness during stand-down periods, to provide an Alert Force and ensure sufficient manpower "to offset, in some measure, the unavoidable delays involved in recalling men who were away on pass." An associated problem was the possible saturation of telephone services. The rate of recall would be "far too slow to enable the planned generation

[54] Ibid, 321-322.
[55] DEFE 25/18; "Bomber Command", note, January 4 1960.
[56] Ibid.

rate to be met."[57] Guidance was sought on a suggestion that radio and TV be used to recall personnel, but this was avoided during the Cuban Crisis two years later, in the interests of "unobtrusive" response.

The new regime required an increase in manning establishments, to provide a two-shift, 18-hour working day.[58] Progress accelerated and on February 8 1960 the AOC-in-C Bomber Command, Sir Kenneth Cross, declared that the MBF now met Readiness requirements seven days a week – several months ahead of forecast. Efforts were made to make weekends on base "more acceptable". Cross wanted more recreational/gym facilities, but had no success with his call for swimming pools. Some weeks before, in a letter to the CAS, Marshal of the Royal Air Force Sir Dermot Boyle, Cross made a prediction which proved accurate: "Restrictions on liberty of individuals on such scale, added to the inconvenience of working an 18-hour/two-shift system, particularly against the background of an almost universal five-day week, is bound to become a real hardship as time goes on."[59]

Ironically, later in 1960 there was a big fuss over a Bomber Command request for more "Essential Residential Telephones". Air Commodore C.G. Stowell complained to the Director of Operations (Bomber and Reconnaissance) on December 16: "At present I am under fire from Headquarters, Bomber Command", following the request for more telephones. "These are in the main to alert personnel under the Alert and Readiness Plan. I have not seen this Plan in detail … I am not convinced that Essential Residential Telephones are the answer or that the telephone is the best way to alert personnel." Stowell went on to suggest that Bomber Command had already been "indulged" with extra telephones because of the importance attached to the deterrent.[60] It is possible that he might have been less preoccupied with telephones had he had an opportunity to read *The nuclear destruction of Britain*, published two decades later. Dr Magnus Clarke (1982) made a rare attempt to quantify the consequences of failure to deter a nuclear attack on Britain. He put the immediate effect of a 188-target, 167MT strike on Britain at 6-8 million immediate

[57] AIR 2/17801, "Readiness of the MBF at weekends," letter from Group Captain A.H.C. Boxer, for AOC-in-C Bomber Command, to the Under Secretary of State, Air Ministry (D. of Ops. (B.B.M. & R)), July 20 1960.
[58] Humphrey Wynn, Air Historical Branch (RAF), "The RAF in the postwar years: The bomber role 1945-1970" (1984), 44.
[59] AIR 20/10618, "Readiness of the MBF," letter from Air Marshal Sir Kenneth Cross, AOC-in-C Bomber Command, to CAS, February 8 1960; letter from AOC-in-C Bomber Command to CAS, November 9, 1959.
[60] AIR 2/17801, "Essential Residential Telephones in Bomber Command", letter from Air Commodore C.G. Stowell to D. Ops. (B&R), December 16 1960.

fatalities and 10-16 million seriously injured. There would be 31-39 million able-bodied survivors one month after the attack. After three months, there would be a minimum of 20 million dead from all causes, with exhaustion of food stocks between three and six months after the nuclear strike. Food would become the means of government. Thirty years after the attack, the UK population would have declined to about 10 million, mostly living a rural existence.[61]

On the frontline

V-Force aircrew were in their twenties or early thirties for the most part, although some (especially in the early days) were more mature – in their forties or even fifties. Many did not regard a V-bomber posting as first prize. The younger men enjoyed the traditional pursuits of young flyers. Beyond the serious matters of flying training and Target Study, they had little thinking time for what many called, irreverently, the "Nuclear Detergent". The bomb itself became known as "the bucket of sunshine" or, simply, "the bucket". Vulcan Co-Pilot Keith Mans, with 50 Squadron at RAF Waddington, summed it up: "For a young man in the V-Force, the nuclear deterrent element was the most boring part of the job. The really interesting bit was flying long-distance – going abroad. Naturally, the most popular destinations were the sunspots, such as Cyprus."[62]

Operational deployments often took crews to the sun. Occasionally, an aircraft deployed to RAF Luqa, Malta. Crews flew low over the desert when using El Adem bombing range in Libya. Bombing practice over ranges in Libya, Cyprus and Malta involved trips of three or four days. Western Rangers lasted longer – about a week – and often called for low level sorties over Goose Bay, Labrador, to practice flying over the Arctic tundra. Western Rangers might also involve use of USAF Radar Bomb Scoring Units (RBSUs) or Nike SAM sites. Many Western Rangers terminated at Offutt Air Force Base (AFB).[63]

Keith Mans was 22 on joining 50 Squadron. He had a strong belief in deterrence: "I had no personal qualms about nuclear weapons. They emerged from the 1950s ethos, which was to avoid repeating the errors of the 1930s and attempts to appease Nazi Germany. This time there would be no appeasement."[64] There were few

[61] Dr Magnus Clarke, *The nuclear destruction of Britain* (London: Croon Helm, 1982), 238-240.
[62] Keith Mans, Vulcan Co-Pilot, 50 Squadron, RAF Waddington; documents/text provided: 17/11/20.
[63] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 2/4/20.
[64] Keith Mans, Vulcan Co-Pilot; documents/text provided: 17/11/20.

philosophers on the squadrons. No-one dwelt on the possibility that the deterrent might fail. Nuclear war was avoided as a topic of conversation, both on base and at home. It might have been considered bad form to bring up this subject out of the professional context. Vulcan Captain Paddy Langdown, also on 50 Squadron, had a typical attitude: "We were going to drop it on the Russians only if they dropped it on us. If called upon to do so, I would have gone. That was it. We gave it no further thought."[65]

AEO Martin Anscombe flew his first sortie with his Captain as 50 Squadron Commander on August 8 1961. Newly-arrived crews buckled down to intensive Target Study. On a war flight, one of the AEO's many duties would be to manage Morse communications. "This was the most reliable of all means of communication for crucial messages, including 'POSREL' – the message required to cross the 8 deg. E Go/No Go line." Anscombe raised eyebrows when he rigged a small domestic tape recorder to record Morse transmissions and play them back at slower speed – giving him more time to read them and verify.[66]

Robin Woolven was a Nav/Plotter with 617 Squadron, Scampton, flying Blue Steel Vulcans: "So far as I'm aware, everyone around me was completely on-side. We had the weapon, the delivery system and the resolution to use it if we had to."[67]

Confidence in the deterrent was not absolute or universal, as confirmed by Vulcan Pilot John Huggins: "Towering over everything was 'MAD' – 'Mutually Assured Destruction'. In short, if it ever happened, there would be nothing left for anyone. This might seem like a commonsense balance of terror but, for some years, it seemed more a question of *when*, rather than *if* nuclear war would happen."[68]

With squadrons run as separate entities in the days before centralised control of flying and servicing, Nav/Radar Roy Brocklebank remembers the competition to launch the first aircraft at 0800 "start work":

> In practice, groundcrew would be preparing the aircraft through the night, ready for crew in at 0700. The inflight caterers would have been preparing inflight

[65] Paddy Langdown, Vulcan Co-Pilot/First Pilot, 35 Squadron, RAF Coningsby/RAF Cottesmore; Captain, 50 and 101 squadrons, RAF Waddington; interviewed: 9/2/18.
[66] Martin Anscombe, Vulcan AEO, 50 Squadron, RAF Waddington (1961-66); interviewed: 28/2/18.
[67] Robin Woolven, Vulcan Nav/Plotter, 617 Squadron (1964-66), RAF Scampton; amongst documents/text provided: 5/11/20.
[68] John Huggins, Vulcan Captain; documents/text provided: 26/10/20.

> rations and getting ready to serve pre-flight meals at any time after 0500. The crew would assemble in the Briefing Room at 0500. With nine bases and 20 plus aircraft all vying for those 0800 slots, it wasn't going to work. Each station was allocated a number of take-off slots throughout the day, starting at 0800 and then spread through, with last planned launch maybe 2100 that evening. Now, instead of squadrons competing against each other, each station was competing to hit its assigned take-off slots. To that end, the whole process was designed from brief, eat, change, transport, crew in, taxi and rotate at precisely the briefed time.[69]

The next carefully watched check of the station was the post-QRA fly-off. Each week, a QRA aircraft came off-state and was scheduled for a post-QRA sortie: "Other than the standard daily pre-flight, as it had undergone on QRA, no other servicing was permitted except for a rare safety of flight issue. Once the weapon was offloaded, the aircraft would be handed to the crew and all eyes were watching to see if it was a goer."[70]

Confronting realities

Given that the number of V-bombers surviving a pre-emptive strike was central to the delivery of sufficient weapons on targets, what were the full implications of a short warning, hammer blow missile strike on MBF airfields? Uncomfortable realities were confronted in a May 1960 letter from the then ACAS (Ops), Air Vice-Marshal John Grandy, to the AOC-in-C Bomber Command. Grandy noted that recent Intelligence appreciations "conclude that the Soviets have available a number of IRBMs. The tactical warning available on this missile threat could be as low as three minutes for an IRBM launched on a low trajectory from Eastern Germany, but this amount of tactical warning will not be available until 1963, when BMEWS is expected to be operational."[71]

Grandy also referred to the growing Soviet challenge in the air:

> Successful deep penetration of the Soviet defences is likely to become increasingly complex, since more targets are being protected by the installation of short range SAGW systems, to supplement the existing large fighter force. Both an increased ECM capability and Blue Steel Mk. 1 should become available to your Command within the next 2/3 years, and it is important to study the extent to which these aids to penetration can be maximised.[72]

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[69] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 6/4/20.
[70] Ibid.
[71] AIR 2/18103, "Effectiveness of Bomber Command in the immediate future (ie. until the beginning of 1965", letter from Air Vice-Marshal John Grandy, ACAS (Ops.), to AOC-in-C Bomber Command, May 13 1960, ACAS (Ops.) CMS. 2609/55/F.1351(S)/Ops. 4020.
[72] Ibid.

Efforts were made to reduce the threat of destruction on the ground. Many innovative measures were taken, mostly contributing to faster scramble times (including construction of ORPs and introduction of SIMSTART). While a new realism pervaded Bomber Command, false hopes and excessive optimism lingered. In the early, pre-missile days, the war Standard Operations Plan (SOP) first edition assumed the V-Force would make two or three attacks, rather than one. Having flown their first war sortie, Captains landing away were expected to contact base or the resident Air Attaché for instructions! A note from the DCAS to the Secretary for Air in February 1958 set out Air Staff expectations of MBF sortie potential (based on 144 aircraft with 75% serviceability and allowing for losses inflicted by the enemy):

- First strike: 86 aircraft reaching target area and 58 “effective bombs”.
- Second strike: 55 and 35.
- Third strike: 42 and 28.[73]

This would put 121 weapons on targets. The note commented on estimated losses:

> It is of course impossible to predict accurately the losses which the enemy could inflict on our bombers. This will depend on tactics, routes, time of day or night, location of the targets and the effectiveness of the Russian defences. Making due allowance for all these factors, however, the best estimate that can be made is that casualties might vary between 54% or even higher for the Valiants to as low as 22% for the Mk. 2 Victors/Vulcans with the powered guided bomb. In our calculations, we have, in fact, taken a loss rate of 20%, which may be a little on the low side but does not affect the issue very materially.[74]

Given the likely catastrophic consequences of a pre-emptive missile strike, even with BMEWS and new measures to get bombers off the ground as quickly as possible, plans for second and third strikes melted away. Yet, chronic optimism proved endemic. Writing in 1993, Sir Frank Cooper (head of the Air Staff Secretariat (1955-60) and, eventually, Permanent Under Secretary for Defence), made a firm claim:

> The V-Force became genuinely credible as an operationally efficient force which would survive. Its ability to disperse first at home and then overseas, its well-publicised ability to maintain QRA and take-off rapidly, the introduction of flight refuelling, coupled with some spectacular long range flights, all contributed

[73] AIR 19/940, “Note on strike potential of MBF”, from DCAS to Secretary of State for Air, February 19 1958.
[74] Ibid.

> to driving home to the East, and almost as important to the public at large, that the V-bomber force was able to survive aggression and would be able to retaliate.[75]

This was written 24 years *after* the UK strategic deterrent passed from the V-Force to the submarines. Sir Frank's highly positive comments contrast with the operational reality, reflecting an embedded tendency to make favourable *public* assumptions about Readiness, available warning time, dispersal, war scramble survival rate and the ability to reach targets. To take just a few of Sir Frank's points: the V-Force had no capacity to launch a retaliatory strike from overseas bases (with the exception of two Vulcan squadrons based in Cyprus for several years post-Polaris handover). There was a difficult period pre-Fylingdales, when the V-Force was exposed to a low trajectory IRBM attack, with poor prospects of sufficient tactical warning. A war scramble involving QRA aircraft alone would have produced very few weapons on targets. As for flight refuelling, that proved irrelevant to V-Force strategic capabilities.

Reaching the target

For those bombers surviving a strike on their airfields, the next challenge was to penetrate the Soviet coastal defence belt. The early plan was to concentrate V-Force aircraft at several crossing points and swamp local defences. A March 1959 Bomber Command report examined the effect of tactical routeing on target coverage. This assumed penetration of the coastal defences via three "gates" – north, central and south, with the central gate offering maximum target cover.[76]

As for weapons, stand-off systems had obvious advantages over freefall bombs. The Blue Boar guided bomb project was cancelled in June 1954, but, just three months later, OR. 1132 was issued for an air-to-surface weapon for the V-bombers. This became Blue Steel 1, which would allow carrier aircraft to "stand-off" target point defences. Blue Steel was required by 1960, but delivery slipped to December 1962.[77]

When considering Blue Steel 1, views should be tempered by the pressures of the time. Professor John E. Allen (1999) described a series of Blue Steel decisions "taken in the presence of considerable ignorance of the consequences ... Due to the urgency of the Blue Steel project, about 95% of all irrevocable decisions in project design had

[75] The Rt. Hon. Sir Frank Cooper, GCB, CMG, PC, "The direction of Air Force policy in the 1950s and 1960s," RAF Historical Society, *Journal 11* (1993): 10-21.
[76] AIR 14/4208, Bomber Command, Operational Research Branch, Memorandum No. 24, March 1959, "The effect of tactical routeing on target coverage."
[77] Wynn, *RAF nuclear deterrent forces*, 186-189.

to be made when only a few percent of the total project data were available." Certainly, the RAF was desperate for the stand-off weapon and this pressure contributed to its immunity from cancellation, despite a suite of rather obvious disadvantages.[78]

The operational need was urgent, but could this weapon be made to work? The accuracy expectation was 500 yards at 150NM, using autonomous inertial navigation. Doubts about Blue Steel's operational value were expressed as early as 1958. The Air Staff wanted a stand-off weapon with a much longer range. A view expressed in October of that year, on the basis of an estimate by the Ministry of Supply that Blue Steel Mk.1 would be in service early in 1962, was that by 1963 the V-bomber/Blue Steel Mk. 1 weapon system was unlikely to constitute a valid deterrent, owing to the reducing ability of aircraft to penetrate to the weapon's required release point."[79] And that was *long before* Blue Steel's range was cut by two-thirds, to 50NM or less, when the V-bombers went low level. Nevertheless, Blue Steel's production order was placed in December 1960 (eventually finalised at 57 missiles).

This unease contributed to wider concerns about the fundamental vulnerability of a bomber-based deterrent. Champions of the bomber regarded missiles as unproven and pressed for a new generation supersonic bomber. Certainly, there were deep concerns about the survival prospects of subsonic bombers in heavily defended airspace.[80] Most advocates of bombers supported the case for the long range powered bomb (OR. 1159, Blue Steel Mk. 2) – an option offering greater credibility and life extension for the force.

Life extension

In mid-1955 A.I. Llewelyn, then Bomber Command's Chief Research Officer, set out options for V-Force life extension.[81] Responding to a reply from the AOC-in-C, Llewelyn (loose minute, August 30 1955) claimed the V-Force "will have a better life than people think", that countermeasures against radars would reduce fighter effectiveness and, furthermore, "the guided missile defence will take longer and be much less efficient than people think".

[78] Professor John E. Allen, former Chief Future Projects Engineer, BAe, Kingston, "Blue Steel and developments," The history of the UK strategic deterrent, Royal Aeronautical Society, March 17 1999, London.
[79] Wynn, *RAF nuclear deterrent forces*, 198.
[80] Gibson, *Vulcan's hammer*, 21.
[81] AIR 14/4198, "Extending the life of the V-bomber force," Bomber Command: TS Memorandum No. 14, July 26 1955.

Llewelyn identified six life extension options: aircraft performance, aircraft tactics, force tactics, countermeasures, use of decoys and use of support (eg. opening attacks by Canberras on reporting and control radars). On aircraft performance, there was limited scope for pushing height and speed within buffet boundary limits and the range of the flight. On aircraft tactics, the main choice was high or low. Here, he argued for low level attacks against "a certain proportion of targets within a limited range". Force tactics hinged on dispersal in time and space, with limited dispersion the "reasonable compromise".[82]

In the mid-1950s there was time to take considered response decisions; hostile bombers would give ample warning in that very different, pre-ballistic missile world. Llewelyn was prompted to observe:

> Although statements have been made that the bomber force must retaliate instantly, whether by day or by night, there is no denying the fact that by day the probability that a reasonable percentage of bombers reach their targets is very small. Plans must therefore be based on night attacks if we wish to retaliate effectively and not just make an ineffective gesture.[83]

On countermeasures, Llewelyn referred to chaff ("Window"), Airborne Interception (AI) jammers and warning equipment: "… the continued survival of the V-Force as the Russian defences improve will depend on the success with which these measures can be introduced and used." The Chief Research Officer was not above referring to "exotics", including concepts for unmanned, ECM-equipped decoys. It had been suggested that a decoy would cost only 1/30th of a V-bomber and that scaling back the V-Force by 20 bombers would fund 600 decoys. Unfortunately, these calculations were wrong – they failed to take account of decoy assembly site and launch site costs. This reduced the cost advantage to 1/6th of a bomber. Nevertheless, decoys represented a genuine but undeveloped option for reducing bomber losses.[84]

As might be expected, Llewelyn argued for the powered bomb: "… it would delay the obsolescence of the V-bomber force at least until an effective long-range guided weapon defence had been introduced."[85] Not only was Blue Steel 1 required, as early as possible, but also an Air-to-Surface-Missile (ASM) with much greater range, yet this need was never satisfied. A 1959 report, from the British Nuclear Deterrent Study

[82] Ibid.
[83] Ibid.
[84] Ibid.
[85] Ibid.

Group, concluded that long range Blue Steel 2 would increase V-bomber life for only a short period and that Skybolt was preferable. The following year a Memorandum of Understanding was signed for the purchase of 100 Skybolts.

Skybolt and the future

With missiles deployed in ever greater numbers, the catastrophic consequences of pre-emptive strike became self-evident. Air Vice-Marshal Menaul (1980) acknowledged the threat: "… this demanded new safeguards for the deterrent strike forces which, in turn, ushered in 'counterforce strategy', which dominated strategic thinking in the early sixties." There was a persistent focus on getting weapons on targets rather than the essential prerequisite – surviving a pre-emptive strike. The Skybolt ALBM made the point. Widely regarded as the future of the British deterrent, this weapon system (aircraft, missile and crew) would have become increasingly exposed to destruction on the ground. Nevertheless, according to Menaul: "Both Bomber Command and SAC were convinced that an air-launched ballistic missile was a logical and desirable step in the development of strategic nuclear forces."[86] As things turned out, it seems that Bomber Command (on the face of it, at least) was more convinced than the Americans, despite the fact that Skybolt would have been less capable in British service, due to the inability to adopt SAC-style Airborne Alert.

With Skybolt's cancellation in late 1962, the bombers' vulnerabilities remained. What more could be done to reduce V-bomber casualties on the ground and in the air, in the event of a hot war? A convincing response was needed, to preserve the core retaliatory threat. The solution adopted was ultra-low weapons delivery.

In summary, V-Force vulnerabilities on the ground and in the air are identified in this chapter and will be examined in detail later in the thesis narrative. In terms of operational effectiveness, this chapter notes the emergence of more realistic attitudes towards the missile threat to the MBF, prompting a programme to develop dispersal airfields, to introduce round-the-clock QRA (to present a minimum retaliatory threat at all times) and enhance the process for generation/dispersal/regeneration of weapon systems. As for vulnerability in the air, the lack of an advanced weapon following Skybolt's cancellation and, hence, the need to penetrate Soviet defences, prompted the switch from high altitude attack to ultra low level penetration – the factor dominating V-Force operational planning from 1963 onwards. There were also

[86] Menaul, *Countdown*, 93,105.

important developments in the control of the retaliatory process, especially the decisions concerning delegated authority and “positive control” of bombers in the air.

– 3 –

THE TARGETS

Given the relatively modest size of the UK nuclear stockpile, the first principle of UK planning was to make every weapon count. This chapter describes British targeting policies, accommodating Plan A (the NATO coordinated war plan) and Plan B, a National list of countervalue targets – Soviet cities (the maximum threat from limited means). It is argued that there was little difference between Plan A and Plan B, in terms of the consequences of an attack, as many priority military targets were located within the greater boundaries of the major cities. The evolution of targeting policy is discussed, with its eventual concentration on the very largest Soviet cities. The chapter also considers the measures taken to maximise the destructive potential of each weapon in relation to the allocated target (in itself an explanation of the V-Force emphasis on accurate weapon delivery).

Making every weapon count

British nuclear targeting policy was astute and pragmatic. V-Force crews trained to attack Plan A (NATO/SIOP) and Plan B (National) targets. Plan A targets were primarily "counterforce", such as airfields, ports, missile sites and command and control centres. Plan B "countervalue" targets in the National Plan focussed on the biggest cities, presenting the maximum threat from UK nuclear forces acting alone. In the public arena, Plan B was often discounted as so unlikely as to be hardly worthy of discussion. Yet it remains, to this day, the ultimate foundation of UK military and political power. Inevitably, given Britain's limited nuclear assets, Plan B targets were punitive: the major centres of population. At the same time, Plan A military targets were often near or within major urban areas and, consequently, as Kristan Stoddart (2012) has pointed out: "… there was little difference between these and the countervalue (city) targets that were the focus of the National Retaliatory War Plan."[1]

Each V-Force crew had at least two Plan A NATO targets, a Plan B National target and a priority QRA target. Roy Brocklebank was Wing Targeting Officer for Waddington's 24 Vulcans: "There was one QRA target (ALN 100 series), two Plan A (ALN 200 series), one Plan B (ALN 400 series) and one Plan B follow on target (ALN 411 plus)."[2] Targets changed annually (Plan A on July 1 and Plan B on January 1), so presenting each crew with fresh

[1] Stoddart, *Losing an empire and finding a role*, 234.
[2] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 2/4/20.

challenges. This cycle allowed for Intelligence updates and changes in targeting policy. Destroying airfields and other military targets might be thought an inadequate response to Britain's total destruction. Most counterforce targets, however, were in and around the big cities; a Plan A attack would largely destroy the host cities (at least those not already destroyed in earlier missile strikes). A V-bomber counterforce strike would inflict catastrophic countervalue damage. From this perspective, both plans were in harmony. In this respect, Lawrence Freedman (2003) drew attention to an early comment by T.F. Walkowicz (1955): "… major air bases are frequently located near cities; troops can be concentrated in cities; and submarine bases are associated with major seaports. Thus, even counterforce operations will inevitably lead to some destruction of Soviet cities."[3]

Early V-Force targeting had a counterforce emphasis, with priority given to Soviet Long Range Air Force (LRAF) bomber bases threatening the UK. This was accompanied by countervalue targeting in the National context. Here, the objective was to destroy major urban areas. Matthew Jones (2018) points to the logic:

> This was, after all, the purest way to achieve a deterrent effect: to inflict such a level of destruction on a society and state that it might cease to function in any recognisable manner, making the potential gain of any initial aggression seem insignificant and even ridiculous against the disastrous consequences that would follow as a result. In the strategic environment, where the UK's delivery capabilities were decidedly limited but the power of weapons carried much increased, the attractions of countervalue targeting became steadily more apparent.[4]

The Valiant entered service in February 1955. Two months later Bomber Command's then AOC-in-C, Sir George Mills, was asked to comment on his draft Command Directive. He was unimpressed. Attacks on the Soviet long range bomber force had priority. While many air bases were near cities, Mills made it clear in a letter to Air Vice-Marshal L.F. Sinclair that he preferred the cities proper.[5]

The British allocation of Plan A targets, under SIOP, evolved over the years, as did the Plan B National target list. These changes reflected, *inter alia*, a shift in policy from instant and massive nuclear retaliation to "flexible response". Plan B placed emphasis on an ever smaller number of the largest Soviet cities. While the British definition of levels of damage unacceptable to the Soviets became increasingly modest, this did not solely reflect a steady

[3] Lawrence Freedman, *The evolution of nuclear strategy,* Third Edition (Basingstoke (UK)/New York: Palgrave Macmillan, 2003), citing Colonel T.F. Walkowicz, "Counterforce strategy: how we can exploit America's atomic advantage", *Air Force Magazine* (February 1955): 51.
[4] Matthew Jones, *The official history of the UK strategic nuclear deterrent: Volume 1: from the V-bomber era to the arrival of Polaris, 1945-1964* (London/New York: Routledge, 2018), 35-36.
[5] Ibid.

decline in V-Force operational capability during the 1960s, but also a shift in purpose – to a threat of damage severe enough to *undermine the balance between the superpowers*. From the first, British planners sought to make the most of the UK's relatively modest nuclear stockpile. Their task was to maximise the deterrent threat and, secondly, in the event of war, to maximise damage. Mark Venables (1985) set out the realities: "Britain's strategic forces continued to plan to attack cities, obliged by the balance of geography and military capabilities to rely on a deterrent threat through punishment rather than denial ..."[6]

"Optimisation" of nuclear strike capabilities was the watchword. Bomber Command's Operational Research Branch (ORB) produced a seminal report on this subject in 1959: "The effect of delivery accuracy and target allocation on the effectiveness of a nuclear stockpile":

> The stockpile … can be taken to represent the potential destruction of an area of enemy resources. How far the practical results of an offensive using these weapons would fall short of this potential depends on many factors, amongst which are accuracy of delivery, degree of assurance or target coverage required on individual targets, and the disposition of aiming points within a complex target. Lack of accuracy in delivery will always waste some potential damage capability. If the ratio of delivery error to weapon damage radius is more than 1.0, this loss in potential is serious.[7]

The memorandum underlined the need for a pragmatic approach to targeting:

> Economic use of the damage potential of the stockpile and good coverage or high assurance on individual targets are incompatible, so that planning must be a compromise between priority needs and optimum overall use of the weapons available. Disposition of aiming points within a large, complex target is necessary, to prevent the serious over-hitting (and consequent loss of effectiveness elsewhere) which occurs if only one aiming point is chosen. In order to achieve the maximum damage to built-up areas in Russia, the majority of weapons would have to be allocated to the few large towns.[8]

This report described the rationale behind target allocation. The destructive potential of a stockpile can be measured in terms of total area of effect. For example, the potential of 20 1MT weapons would be about 250 square miles, if the target consisted of built-up areas. However, the actual area of destruction caused "would be very much less than this". Some weapons would fail to explode, others would detonate with less than nominal yield, and, of course, some bombers would fail to reach their targets. Here, the memorandum noted: "These

[6] Mark Venables, "The place of air power doctrine in postwar British defence planning and its influence on the genesis and development of the theory of nuclear deterrence, 1945-1952", King's College, London (1985).
[7] AIR 14/4287, Bomber Command, Operational Research Branch, Memorandum No. 199, "The effect of delivery accuracy and target allocation on the effectiveness of a nuclear stockpile," c.September 1959.
[8] Ibid.

are well-known factors, but there are others, stemming from the way in which it is planned to allocate and deliver the weapons, which are less often considered."[9]

The memorandum used the term "utilisation" to measure magnitude of weapon effects: "This 'utilisation' is simply the proportion of the nominal destructive area of a bomb which can be expected to be effective in practice when it is used against an area target." As for delivery accuracy, it might be thought that, given the immense power of nuclear weapons, precision is of little consequence. The memorandum, however, describes a more complex reality: "If the target and the damage radius of the weapon are both large compared with the accuracy of delivery, the expected utilisation of the weapon will be high." At the same time, it acknowledged that this was not always the case, adding:

> The effect of delivery error on bomb utilisation is most pronounced when the target is comparable in size with the damage radius of the bomb, a frequent practical situation. In this case, utilisation falls below 50% unless the delivery error is much less than the bomb damage radius. Any reduction in delivery error which can be made is well worthwhile in this case. If the target is larger than the bomb damage radius, one bomb will achieve almost its full effect unless the delivery error is greater than the bomb damage radius. Against smaller targets, the full potential of the weapon cannot be realised because a proportion of the area of effect necessarily occurs beyond the target boundaries. This initially low utilisation is decreased further if there is appreciable delivery error.[10]

This explains why Bomber Command placed so much emphasis on accurate delivery of nuclear weapons, despite their enormous power.

The achievement of high accuracy was fundamental to optimised utilisation. The memorandum, when considering allocation of weapons to targets, stated:

> The normal procedure in planning is to allocate weapons to a target (taking into account delivery accuracy) so that a certain proportion of the target can be expected to be damaged or so that there is a given assurance of damaging at least some specified proportion of the target area. These two methods, while they differ considerably in concept, are interchangeable in practice, in that they define a number of weapons to be allocated to the target, the end result of this allocation being interpreted either as an expected result or a high chance of achieving some smaller effect.[11]

The ORB report demonstrated how the expected average utilisation of the bombs allocated varied with the proportion of the target expected to be damaged and with target size, if the accuracy of delivery is known to be equal to the damage radius of the bomb. "Against small

[9] Ibid.
[10] Ibid.
[11] Ibid.

targets, bomb utilisation is necessarily low, since a major part of the potential effectiveness of the weapon is dissipated beyond the target boundaries. As target size increases, utilisation of the weapon increases to a maximum and is then reduced slightly for the larger targets." If weapons are all aimed at the target centre, utilisation is reduced due to over-hitting the central area. This is reduced by distributing aiming points across the target area … "it is clear that distributed aiming points are essential if bomb utilisation is to be maintained at reasonable levels on the larger targets."[12]

This suggests multiple strikes on the same large target, with "Desired Ground Zeros" (DGZs) distributed over various military assets in the vicinity, to maximise counterforce *and* countervalue damage – often realising both Plan A and Plan B objectives simultaneously. The memorandum warned that very high expectations regarding damage levels drastically reduced utilisation: "… if good target cover (which is equivalent to a high assurance of smaller cover) is required, the expected utilisation of the bombs allocated is reduced. For example, if the target has twice the radius of the weapon effect, an increase in planned target cover from 60% to 90% results in a decrease in expected bomb utilisation from 60% to 30%."[13] So, if the plan requires a target to be very severely damaged, a reduction in the stockpile's potential total effectiveness must be accepted.

Destruction of the largest Soviet cities by British bombers was a feature of both Plan A and Plan B targeting. Plan A provided for strikes against a number of military targets distributed over the greater target area, to maximise "utilisation". These would have been the DGZs in the biggest cities and, if attacked accurately, would have maximised both Plan A and Plan B damage.

Multiple strikes on big cities

Memorandum No.199 offers an insight into the policy of multiple strikes on the largest targets, Moscow and Leningrad, essential given the likely high V-bomber casualty rate:

> A distinction should be drawn here between the allocation of many weapons to a target in order to achieve a high level of damage and a similar multiplication of effort as an insurance against non-delivery. In the first instance, which, it should be emphasised, is the case being considered here, it is assumed that all weapons allocated are delivered; in the second, only a proportion of the weapons allocated are expected to arrive and average bomb utilisation will often be determined principally by this proportion. The cost of insurance of this kind must be accepted, because of tactical and strategic priorities. In many cases, however, it should be possible, by appropriate choice of aiming points,

[12] Ibid.
[13] Ibid.

> to increase the overall effect of the weapons allocated (in the event that more than the expected number arrive), without seriously affecting the assurance of damaging the priority element of the target. This practical planning problem has to be investigated specifically for each target situation; no general solution is possible.[14]

The memorandum's conclusions reinforce the "marriage", in actuality, of Plan A and Plan B outcomes. The UK's limited means promotes an inevitable focus on relatively few targets, the very largest cities.[15]

This is how British targeting evolved, eventually concentrating on the five largest cities (with the focus on the first and second cities). This was the most appropriate course, as only a small group of bombers would be likely to survive a missile attack on their bases *and* successfully penetrate to their targets. The potential for a successful unilateral strike against the biggest cities by very few aircraft was the core of UK deterrence and credibility as a nuclear power. The UK stockpile in 1959 (the year Memorandum No. 199 was produced) consisted of 58 Blue Danube bombs and 20 Yellow Sun 1 400KT weapons, a total stockpile of around 9MT.[16] The ORB report commented: "If larger weapons were available, very few could be used against built-up areas without utilisation falling to low levels. For example, if 1MT weapons (delivered by bomber) were available, only eight could be allocated to Russian towns, two on Moscow and one each on the next six largest towns. To allocate more such weapons for the attack of buildings would necessarily involve a waste of potential effectiveness …" [17]

The Americans and Russians, of course, with their huge stockpiles, had no concerns about wastage of destructive potential on a per weapon basis. The UK was in an entirely different position – every bomb had to count.[18]

It can be argued that QRA aircraft were Plan B (National) targeted, even if the targets were, officially, Plan A SIOP. The overriding operational need, in delivering a relatively modest minimum retaliatory threat, was to inflict maximum damage with few weapons, with DGZs (military centres or not) within the leading two or three cities. The strongest direct evidence for this interpretation is the testimony of a former Waddington Wing Targeting Officer, responsible for managing the targeting of 25% of the MBF. Roy Brocklebank knew of plans for a near simultaneous "assurance" attack by at least five QRA V-bombers (out of a total QRA force of

[14] Ibid.
[15] Ibid.
[16] Norris and Kristensen, *The British nuclear stockpile*, 69-75.
[17] AIR 14/4287, Bomber Command, Operational Research Branch, Memorandum No. 199, "The effect of delivery accuracy and target allocation on the effectiveness of a nuclear stockpile".
[18] Ibid.

11 aircraft) on Leningrad, so maximising the chance of getting at least one weapon detonating on Russia's second city. Logically, Moscow would be the target for the remaining six QRA bombers. Each crew received a TOT with a tolerance of plus or minus three minutes: "The near simultaneous TOT on Leningrad, a National Plan QRA target, was a feature of Plan B."[19] Commenting on the distribution of weapon aiming points across Leningrad, he added: "Certainly, the distribution of DGZs around Leningrad met the requirement for target area coverage."[20] He explained: "At least two QRA aircraft from the three squadrons at RAF Cottesmore were covering Leningrad. When I subsequently arrived at RAF Waddington, QRA aircraft from all three squadrons were also covering Leningrad, although with different DGZs."[21]

The idea was to swamp the target defences, a strategy kept from the crews, for obvious reasons (all former aircrew contributors to this research - other than Roy Brocklebank - displayed no knowledge of this tactic):

> The crews were not allowed to discuss their individual targets. They had no idea that they were tasked to attack the same target, at practically the same time. Separation was down to as little as one minute for Leningrad, in some cases. In other words, attacking aircraft would be destroying other squadron aircraft. The QRA concentration of force was planned to destroy at least one or two very important cities, similar to London and Birmingham.[22]

Given the likelihood of very few V-bombers surviving a pre-emptive missile strike, there were obvious operational arguments for targeting *the entire force* at, say, the top five cities (or even Moscow and Leningrad only), to maximise the threat from the small group of survivors. This must have exerted a strong influence on British targeting policy, which moved from a multiplicity of counterforce and countervalue targets to a handful of large cities, with the destruction of Moscow and Leningrad as the core retaliatory threat. The two leading cities were certainly targets for the powered bomb. Vulcan Captain Philip Goodall commanded 27 Squadron at Scampton, equipped with Blue Steel: "My crew's target was Pulkovo Airport, Leningrad … We would climb to high level over the North Sea and then descend over the Baltic Sea, keeping as far to the north as possible and approaching Leningrad over the sea, with the aim of launching our Blue Steel about 50 miles from the city."[23]

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[19] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter, amongst documents/text provided: 25/6/20.
[20] Ibid, note: 22/8/18.
[21] Ibid, amongst documents/text provided: 25/6/20.
[22] Ibid.
[23] Philip Goodall, *My target was Leningrad, V-Force: preserving our democracy,* (Stroud (UK): Fonthill Media, 2015), 134.

Moscow was an obvious Blue Steel QRA target, as the stand-off bomb, even with its much reduced low level range, offered the best available chance of penetrating the capital's three rings of SAM defences.[24] Roger Smith was a freefall Vulcan Pilot: "We always assumed the Blue Steel aircraft at Scampton would concentrate on Moscow and Leningrad. We were not aware of the targets and TOT of other crews but it was obvious that there would be more than one aircraft going for the big cities."[25] Roy Brocklebank adds that Leningrad, as a prime Plan B countervalue target, second only to Moscow, was also a major military target – headquarters of the Baltic Fleet and the Leningrad Air Defence District. Generally, the lower the ALN, the higher the target priority. "The same target might have different ALNs, but with a different TOT, to allow for a separation in release times for a multi-weapon strike. The TOT allowed for plus or minus three minutes. On one particular target with a planned 10 minutes between strikes, the absolute minimum time separation between detonations was four minutes (equivalent to 22 miles), with a maximum of 16 minutes." At least, that is what the crews were told. "In a multi-weapon attack on the same target, the first aircraft would release, fly on for about 1.5 minutes, execute a 180 deg. turn, fly low until abeam the target and climb away. This could take it dangerously close to an early second detonation. The logic for this turn back might have been to take advantage of the local effects of their own bomb."[26] An alternative explanation would be an attempt to confuse any surviving defences, encouraging them to assume that the returning "decoy" bomber had yet to release. All V-Force contributors discussing this issue appeared to accept the official explanation. Yet, it seems likely, taking account of TOT manipulation, that the true purpose of the return to the cloud was another chance to confuse the defences (although no direct evidence for this was found).

With each crew having QRA, National and Plan A targets, Target Study required application, as recalled by Victor Nav/Radar Norman Bonnor: "In the NATO SIOP, we had two ALNs to study and prepare: flight plan (Nav/Plotter), fuel plan (Co-Pilot), ECM plan (AEO) and target/fix point acetates (Nav/Radar). The latter were used on the Plan Position Indicator (PPI) screen to enable map-matching… Later, I think the Joint Air Reconnaissance Interpretation Centre (JARIC) prepared something for us using U.2/satellite imagery, which we could add to if we wished."[27]

[24] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter, amongst documents/text provided: 25/6/20.
[25] Roger Smith, Vulcan Co-Pilot, 12 Squadron, RAF Coningsby/RAF Cottesmore; Captain, 35 Squadron, RAF Cottesmore; interviewed: 11/12/18.
[26] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.
[27] Norman Bonnor, Victor Nav/Radar; letter, amongst documents/text provided:1/11/20.

Roy Brocklebank confirmed the enhanced JARIC output: "JARIC provided more when we had to penetrate at low level – route and fix point booklets with fairly complex radar predictions, including hill shading. The more experienced crews were assigned the more important targets."[28]

When on 100 Squadron, Norman Bonnor's targets included Tallinn and Riga, "or, probably, the air defence centres/fighter airfields nearby. Earlier, on XV Squadron, I think Leningrad was one of mine. On the National Plan, my target was always Moscow – but maybe with different aiming points. Many of our targets were in the Baltic States. Part of our job was to punch through the Soviet air defences, clearing the way for SAC's B-52s. We were tasked to destroy the coastal belt defences. Consequently, Riga was one of my targets." [29] Many SAC bombers would have entered Russia by crossing the Baltic coast, rather than using the "over the Pole" route.[30]

Roy Brocklebank confirmed that V-Force War Plans changed annually. New plans were introduced six weeks before they took effect, to allow primary crews time to prepare the maps and charts and give secondary crews time to become fully familiar with them.[31]

Confidence in the deterrent was strong, but nothing could be taken for granted and Roy Brocklebank remembers a "bolt from the blue" alert in 1969:

> It was a Friday afternoon and I was on the Ops. Desk, covering for the Duty Ops. Officer, who was on a lunch break. Two of the squadrons were on Ground Training Days. Suddenly, the "Bomber Box" burst into life. As I recall, the message was: "*Attention. Attention. This is the Bomber Controller. Selective Generation. Cottesmore, 12 aircraft. Finningley, three aircraft. Scampton, 12 aircraft. Waddington, 11 aircraft."* Now, I had never heard the term "Selective Generation". We had never had a generation start in normal working hours. We had never had one on a Friday afternoon. I immediately called the OC Ops. and we started the generation. We needed to get crews on the road to Finningley PDQ ("pretty damn quick") and we also had the possibility that crews could have been drinking at lunchtime. In the event, all crews were available. We never knew at the time what it was … I think it was the first anniversary of the Soviet invasion of Czechoslovakia (which began on August 20 1968).[32]

Joint targeting

Early UK and US planning recognised the possibility of war with the USSR by 1957. The US Department of Defense, however, had a "Dropshot" plan ready by 1949 – a contingency for

[28] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 2/4/20.
[29] Norman Bonnor, Victor Nav/Radar; notes, amongst documents/text provided: 1/11/20.
[30] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; note: October 2018.
[31] Ibid, amongst documents/text provided: 25/6/20.
[32] Ibid; letter: 5/7/18.

pre-emptive war using nuclear and conventional weapons. The integration of British and American war plans and target lists began in the 1950s, building on the warm personal relationships linking Bomber Command and the USAAF during World War 2. As Sir Frank Cooper remarked: "… there can be little doubt now that the arrangements for the USAF to return to Britain were agreed informally… between Tedder and Spaatz in 1946 …"[33] Whilst cooperation with the Americans appeared secure, there were good reasons to pursue self-sufficiency: the V-Force would be airborne first and first over the targets – so far ahead of SAC as to be "tactically independent". Furthermore, it would take time to achieve full integration and there was some initial British uncertainty about the level of cooperation attainable.[34]

Yet, over the years, the relationship between SAC and Bomber Command continued to deepen. Philip Goodall remembers the American Flight Commander on his first Canberra squadron – Colonel Dick Cody, who was a kind host when Goodall first arrived on his attachment to SAC. Cody had completed his exchange tour at the RAF Staff College and at Bomber Command. On leaving SAC, Goodall was re-posted to Strike Command Headquarters, with responsibility for nuclear planning: "When I was flying the Vulcan my target had been Leningrad … so I had a close examination to see the total number of nuclear attacks planned on that part of Russia, which I believe was something like 15."[35]

RAF Bomber Command and its USAF counterpart discovered that all British targets were also covered by SAC. In due course, an integrated plan emerged, reflecting the fact that the V-Force would go in first, several hours before the US-based SAC main force. This integrated strike plan took effect on October 1 1958, with Bomber Command allocated 106 targets: 69 cities, 17 LRAF airfields and 20 air defence targets.[36] Cooperation extended to the supply of US nuclear weapons to the RAF. The Anglo-American relationship continued to progress, as noted in a Chiefs of Staff (COS) memorandum of October 16 1957, which made recommendations on the foundation for V-Force strategic target policy: "… it has been assumed that the Western Powers would not take the initiative in starting nuclear war and that we are therefore planning to counter actual Soviet aggression." This note endorsed the view that "if the UK should be forced to take unilateral retaliation against the USSR, the target policy of Bomber Command should be to attack the Soviet centres of administration and population. This is the most effective target system for our limited resources."[37]

[33] Cooper, "The direction of Air Force policy in the 1950s and 1960s," 10-21.
[34] AIR 2/13717, "Study of the present ability of Bomber Command to come to an Alert state," October 28 1957.
[35] Goodall, *My target was Leningrad,* 156-157.
[36] Wynn, *RAF nuclear deterrent forces,* 273-274.
[37] "Strategic target policy for Bomber Command," memorandum by the Chiefs of Staff, October 16 1957 (C.O.S. (57) 224).

The focus on countervalue in the unilateral (National Plan) context was reflected in the associated October 1957 Air Staff paper. This considered 131 Soviet cities and towns with a population exceeding 100,000 (54 of major importance, with governmental, economic and/or military significance).[38]

During the following year, 1958, UK nuclear strike planning envisaged the potential damage inflicted by a 144-strong V-Force as 50% of 40 Soviet cities. According to Twigge and Scott (2014, 71), the destruction of 40 Soviet cities would "render ineffective" over 38 million people, or 30% of the urban population. This scale of destruction came to be seen as greater than necessary. That September, the COS Committee was told by the Air Ministry that the threat to deter Russia from attacking the UK had been reappraised at 30 cities. At that time the Air Staff had concluded that 104 Mk. 2 and 40 Mk. 1 V-bombers could deliver about 50-60 bombs in their first strike against the listed 131 cities. Matthew Jones (2018) looked at the potential consequences: "If the higher figure of 60 bombs was used and several bombs were used against the larger targets, this implied delivery of 35 bombs against 15 cities with populations over 600,000, and 25 bombs on cities which mostly had over 400,000 people (making 40 cities in total)." The casualties would be 8,000,000 killed and the same number injured.[39]

By 1963, however, following Skybolt's cancellation, the ability to destroy a group of 15 major Soviet cities began to lack credibility. Going forward, there were three options: leave the gap uncovered until Polaris, "hire" US Polaris submarines and missiles, or further scale back the "minimum deterrent" threat. In this context, in late 1963, the Intelligence assessment was revised, to a judgement that the Russians would regard the certain destruction of five of their largest cities as an unacceptable risk. Twigge and Scott (2014) summed up the prevailing trend: "In the course of only six years, Bomber Command's ability to threaten the assured destruction of Soviet cities had decreased from over 40 to five – a reduction that reflected Britain's growing inability to maintain a wholly independent second strike capability."[40] However, these developments also had a more complex, multi-dimensional character.

Earlier, the British Nuclear Deterrent Study Group adopted the 30-40 cities "benchmark" capability as a basis for future work. In September 1959 the Joint Global War Study Group produced a report for BNDSG based on an attack on 40 cities in 1970. Matthew Jones (2018)

[38] Jones, *The official history of the UK strategic nuclear deterrent*, 51; citing AIR 8/2201, "Soviet target systems and the ability of the Western Powers to attack them", Annex to C.O.S. (57) 224, "Strategic target policy for Bomber Command."
[39] Ibid, 161.
[40] Twigge and Scott, *Planning Armageddon*, 73.

noted: “Total deaths from blast effects were estimated at over seven million, with another 10 million at immediate risk in target cities from fallout …and a further 23 million people located in nearby areas subject to ‘significant’ levels of fallout.” BNDSG’s Chairman was told informally that these estimates were, in fact, very conservative: they failed to take account of the full effects of fallout and took no account of deaths and injuries by fire. As Matthew Jones points out: “The clear inference was that real casualty figures would be of a far higher order.” A British retaliatory strike could drop the equivalent of 40 million tonnes of explosive in a couple of hours, rather than just under three million tonnes dropped on Germany during a long war.[41]

As for the “benchmark”, in January 1962 JIC considered whether 40 cities was still appropriate, or whether it could be reduced to 20 and, in addition, what would be the minimum number for the deterrent to function. *This assumed no US involvement*. The final report (JIC (62) 10) gave a point score to each city of over 50,000. One point was given for every increment of 50,000, with additional points if the city was a regional administrative centre and/or economic centre, or the location of a significant military headquarters, or served as a major telecommunications hub. The analysis of 40 major cities generated a total of 888 points, the top five accounting for 335 points and Moscow alone receiving 136 points out of the total.[42]

Matthew Jones described the outcome: JIC concluded that destruction of the 40 largest cities would be “quite unacceptable” to the Russians and that the destruction of 20 major cities would be “an unacceptable blow at (the) Soviet long term economy and would seriously weaken the immediate Soviet military potential”. As to the final question, what would be the minimum number of cities representing an acceptable deterrent, JIC confessed: “We cannot give a clear-cut answer”. However, the key conclusion was that “it would not be unreasonable to say that the Soviet leaders would consider that the certain destruction of their five largest cities would put them at an unacceptable disadvantage in relation to the United States”.[43]

This was the crucial point. The 1962 JIC report added: “…it is enough that the force should, by itself, be capable of significantly altering the balance of power between Russia and the US. We believe that the destruction of 20 of the largest cities in Russia (and even possibly the destruction of a much smaller number) would so alter the Russo/American balance that it would be unacceptable to the Russians and that a British force with this retaliatory capability would constitute an effective deterrent …” Having received Prime Ministerial approval, in May 1962 a 15-city benchmark (including Moscow and Leningrad) came into operation for a V-

[41] Jones, *The official history of the UK strategic nuclear deterrent,* 164-165.
[42] Ibid, 293-295.
[43] Ibid, 295.

Force then still anticipating Skybolt.[44] Would a V-Force without an advanced, long range weapon be able to present a credible threat of this magnitude?

A steady reduction in the defined minimum deterrent reflected shrinking force capability *and* a more refined perception of the significance of the British deterrent's capacity to alter the balance of power between the United States and Russia. Baylis and Stoddart (2015) viewed the UK concept of minimum deterrence as a "moveable feast which rested in large measure on force levels and military capabilities, rather than being a hard rule based on certainty …"[45] There was, however, at the same time, a growing appreciation of the significance of the realistic UK potential for undermining the balance between the superpowers.

By the time Royal Navy Polaris patrols began, in 1968, the National target list was a "minimum minimum" of 7-11 cities, including at least 50% destruction of Moscow and Leningrad, with the remainder having populations exceeding 300,000.[46] The "Moscow Criterion" reigned – the assured destruction of the first city, together with a handful of other cities selected under the JIC points system.[47]

The Moscow Criterion provided the focus, given Soviet efforts to protect the capital with Anti-Ballistic Missiles (ABMs); Kristan Stoddart (2012) underscored its significance: "… Moscow continued to be the overriding priority because it indicated to the Soviet leadership that whatever defences they were prepared to put up, the UK would defeat them."[48]

The decline in the damage criterion for deterrence was accepted during the six-year wait for Polaris, in the knowledge that destruction of the Soviet Union's first city and, possibly, one or more of the other largest cities was achievable, even allowing for the difficulties of surviving a war scramble and penetrating Soviet defences. Throughout the 1960s the UK maintained a core retaliatory threat centred on the capacity to destroy one or more of the largest Soviet cities. This threat could not be ignored. This was the view of the JIC. Indeed, on one occasion it had suggested that a threatened strike on just one large Soviet city, given a high probability of success, might be enough to satisfy the UK deterrent need.[49] An increasingly modest view of deterrence reinforced the case against significant investment in V-Force equipment and a new, long range ASM. It was felt that a fast war scramble and going ultra low would suffice to

[44] Twigge and Scott, *Planning Armageddon*, 72.
[45] Baylis and Stoddart, *The British nuclear experience*, 128.
[46] Ibid, 102.
[47] Stoddart, *Losing an empire and finding a role*, 9-10.
[48] Ibid, 46.
[49] Jones, *The official history of the UK strategic nuclear deterrent*, 306.

maintain the core threat: delivery of several weapons on Moscow and Leningrad. Consequently, the British deterrent developed *and maintained* its independent significance. The V-force low level strike mission was enough to preserve Britain's status as a third strategic nuclear power and a second centre of Western nuclear decision-making. The V-Force, even with much diminished capability, provided continuity of threat into the Polaris era. It was this continuity which allowed Britain to maintain its special nuclear relationship with the United States.

Response policies

NATO's early posture of immediate and massive nuclear retaliation was set out in May 1957 (Policy Document MC 14/2), with conventional attack a sufficient trigger. "Tripwire" recognised circumstances in which the Alliance might make first use:

> In the unlikely event of Soviet aggression against the Western Powers with conventional weapons, without simultaneous nuclear air attack, it is conceivable that we might have the nuclear initiative and decide to use it. In this case, we consider that the Allied strategic target policy should be to concentrate initially on destroying the enemy's ability to launch a nuclear attack against the West.[50]

MC 14/2 was succeeded by MC 14/3, "graduated response", in January 1968. Under MC 14/3, a Soviet conventional attack would be countered by conventional forces, with tactical nuclear weapons used in the event of a breakthrough and strategic nuclear weapons held in last resort. Response policy and SIOP evolved over the years, with the Bomber Command/SAC close relationship as its foundation. In the early 1960s, Thors were deployed in the UK and American "E" weapons armed some Bomber Command aircraft. In October 1962, just three weeks before the Cuban Crisis peaked, ACAS (Ops.) sent the CAS a minute on strategic planning by Bomber Command and SAC. This noted that the combined strike plan was subject to the proviso that targets are included "which must be hit in the first strike if the war is to be finished quickly and the damage done to the UK and Western Europe kept as low as possible."[51]

The coordinated plan was rewritten annually. The 1962 edition set out the plan applying from that August 1; this introduced a change in target planning for the British, with MBF/Thor attacks on:

- 16 cities (down from 69 in 1958).
- 44 "offensive capability" targets, such as airfields.

[50] AIR 2/13717, "Notes on UK target selection and coordination, developments over the past 10-12 years," August 26 1960.
[51] AIR 8/2201, "Strategic strike planning by Bomber Command," Memorandum from T.O. Prickett, ACAS (Ops.), to the CAS, October 5 1962.

- 10 “defensive capability” targets, such as air defence control centres.
- 28 IRBM sites.[52]

This succeeded a plan allocating the British 48 cities, six air defence centres and three LRAF bases. The new, August 1962 target list may have reflected US Defense Secretary McNamara’s “population avoidance” doctrine.[53] However, while the new target list gave every appearance of a major shift in emphasis away from cities, many of the 54 offensive/defensive targets were, in all probability, located in and around most of the big cities previously targeted. The note to the CAS sought to convey a picture of “no change” and adopted a rather defensive tone:

> Selection of these targets is by mutual agreement between Bomber Command and SAC and there can be no suggestion of US authorities arbitrarily imposing targets upon the UK strike force. They have been selected to provide the best operational tactical plan. The targets included in current planning fall well within the target system authorised by the Chiefs of Staff. There has, however, been some change of emphasis between the Bomber Command part in the previous and current coordinated plans. The MBF and Thor in the previous plan were directed primarily against cities – 48 cities, six air defence targets and three LRAF bases. In isolation, this could be interpreted as a significant change in the direction of counterforce strategy. However, the coordinated plan for all-out retaliation covers the targets previously allocated to Bomber Command. This plan is therefore fully compatible with the Strategic Target Policy which was formulated against the background of the use of massive retaliation and on the assumption that the Western Powers would not take the initiative and that we would counter actual Soviet aggression.[54]

ACAS (Ops.) acknowledged that the Americans had “other plans” not subject to joint consultation, but claimed these were “compatible” with Bomber Command participation in coordinated action. He gave reassurance: “There has … been no direct suggestion of pre-emptive action in the joint preparation of plans by Bomber Command and SAC.” (The use of “direct” in this sentence is of interest). He continued: “This line has been confirmed in recent discussions between the Minister of Defence and Mr McNamara.” In conclusion, the note stressed that it was “militarily prudent” to have alternative plans. After all, the British had the National Plan. There was, of course, always the thought that the Americans might hold back, in the hope that war could be contained within the European Theatre. Here, the note stated: “Should there be disagreement between ourselves and the Americans … it would still be

[52] Ibid.
[53] Ken Young, *The American bomb in Britain: US Air Forces’ strategic presence, 1946-64* (Manchester: Manchester University Press, 2016), 263.
[54] Prickett, “Strategic strike planning by Bomber Command,” October 5 1962.

possible to direct the MBF to concentrate on centres of administration and population, in the case of unilateral action …"[55]

This also applied to Valiants assigned to SACEUR and carrying American "E" weapons in the NATO role. They could also carry British weapons free of dual control. Valiant Nav/Radar Tony Wright and crew were briefed to attack several targets, including National targets, "where the British Red Beard nuclear weapon would have been used if we had to go to war without the USA."[56]

To summarise, the UK's Plan A and Plan B were two sides of the same coin – different dimensions of what was, essentially, a unified approach backed by a pragmatic view of how elements of these plans might be applied in a variety of circumstances. For example, greater Leningrad could be a Plan B countervalue target or a Plan A counterforce target (if DGZs are military in character). Either way, the DGZs must be distributed across the entire target area, to maximise "utilisation". There was no conflict between Plan A and Plan B objectives. A successful Plan A attack on Leningrad's military facilities would largely destroy the host city and vice versa. Given sufficient surviving V-bombers, the outcome of a successful multi-strike attack would be indistinguishable, under A or B. Certainly, the citizens of Leningrad would notice no difference.

Inside "The Vault"

In January 1967 Squadron Leader Roy Brocklebank arrived at Waddington; he became Wing Targeting Officer and Vault Officer:

> I was custodian of all war targets and responsible for assigning crews to targets every Friday, ready for the following week … The Waddington Wing had three squadrons, each with 11 crews – 33 crews in all. The Wing was allocated 24 targets for each War Plan. This allowed for leave, sickness and new, non-operational crews. We could have six crews on leave at any given time, plus new crews fresh from OCU and still to achieve Combat status, together with one or more crews who might be non-operational for other reasons. The Waddington target list included Leningrad, Kiev, Riga, Kliepeda and Kaliningrad, although I did find maps for Moscow – earlier high level routes. The largest cities, of course, were the most heavily defended. There were other challenges. Kiev, for example, would require two and a half hours at low level going in and another hour and a half at high level getting out.[57]

[55] Ibid.
[56] Tony Wright, Valiant Nav/Radar, 148 Squadron, RAF Marham; Vulcan Nav/Radar, IX Squadron, 35 Squadron, RAF Cottesmore; 50 Squadron, RAF Waddington; interviewed: 26/3/19.
[57] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.

Each V-bomber main base had a "Vault", the secure room with a central role in operational readiness. Brocklebank was custodian of Waddington's Vault for three years. Immediately inside the Vault's inner room, on the wall to the left-hand side, were the "authentication envelopes" containing the codes for "SCRAM" (scramble), "SCRAMCAN" (cancellation of scramble), "RELREAD" (relaxation of Readiness) and "POSREL" (Positive Release – authorisation for a retaliatory attack) … One POSREL code, for exercise use, was "Nourishment". Later, the code was changed to a trigraph, such as J9W.[58]

Target Study

Most factors influencing war sortie outcomes were beyond the influence of crews. Target Study, however, was a prominent success factor very much in their hands. When flying as a Vulcan Nav/Radar, Roy Brocklebank's targets included Leningrad and important military locations, including: Arkangelski Talagi, south of Severomorsk (headquarters of the Soviet Northern Fleet); Baltiysk, an airbase 22 miles south-west of Kaliningrad; Baranovichi, an airbase in Belarus and home to interceptors, Tu-16s and, later, a major centre for the Tu-22 BLINDER; and Starokostiantyniv, in the Ukraine, an airbase eventually taken over by the Ukrainian Air Force in the post-Soviet era. Brocklebank described the context for Target Study:

> When a fresh crew joined the squadron they went straight into intensive Target Study, with the squadron's two QRA targets given priority. They teamed up with an operational crew and went through the procedures for a "weapon system takeover". An aircraft began in the "cold" condition. It was then fuelled, serviced and checked by a crew. Once serviceable, it was bombed up, the weapon system was checked and the Captain checked and signed Form 700, formally accepting the aircraft, at which point the aircraft would be declared combat-ready. Crews would study each of their allocated targets. A Target Study session would include studying the target folders and reading up the latest Department of Defense's *Defense Intelligence Digest*. Crews were given a random check on each target every half year …[59]
>
> Target Study was the name of the game: learn and digest the war SOP Manual …and the target folders. The first three sets were for the SIOP. The first target was the one covered by the squadron when on QRA. The second was the crew's individual principal target. Finally, there was a back-up target, in case the primary crew was not available to take their own primary target. Crews never knew who "owned" the secondary target or who covered their own primary target. We were forbidden to discuss this with other crews and we never tried to find out. The target folder had several components. There was a single sheet of paper setting out all the necessary information: the name, Bombing Encyclopaedia number, SAC ALN and British ALN, its position and the route. Most important was the TOT in minutes, which would give us a clock time based on the "Execution Hour" broadcast at the time of scramble.[60]

[58] Ibid.
[59] Ibid.
[60] Ibid; note: October 2018.

Roy Brocklebank recalled that JARIC prepared three strip maps for each target – one flip-style for the Pilots and two book-style for the Navigators:

> These covered the low level portion of the route. JARIC had also calculated radar fix points and when they would be visible to the radar – the "Fix Box". They also had a very small target photograph, which was really of no use at all. The crew drew up a chart, flight plan and fuel plan. We prepared four versions of the flight and fuel plans, using statistical weather data for each season. This was in case we had no time to update the plans with the true weather of the day. We also had Climatological Data Sheets, with the whole USSR divided into broad climate zones. Each sheet set covered all four seasons.[61]

Much emphasis was placed on Target Study, from the earliest V-Force days. Valiant Co-Pilot Dick Fuller and crew put a great deal of effort into it: "How effective we would have been, in reality, is a matter of conjecture. The Valiant's ceiling was around 45,000 ft, with a speed of Mach 0.82."[62] Target Study was taken very seriously on 12 Squadron. Vulcan Pilot Nick Dennis remembers Target Study as "no bundle of laughs. We were questioned on our knowledge of defences, the required escape manoeuvres and other aspects."[63] Everyone knew there would be no time for more Target Study should the Cold War suddenly become hot. Vulcan Captain Roger Dunsford recalls the regular Intelligence updates, "tracking the movement of mobile SAM sites and other defences."[64] Crews were required to follow the pre-determined routes on JARIC maps showing the track and radar fixes to be used.

Training for war

Could the V-bombers have reached their targets? The outcome would have differed over time. Twigge and Scott (2014) considered the position when the emphasis was on bombers, noting the key decisions of 1957, the definition of the V-Force at 144 aircraft and the agreement to coordinate the nuclear strike plans of Bomber Command and SAC. The Joint Planning Staff report "Allied strategic nuclear attack in global war in 1957" (JP (57) 10) formed a basis for UK strategic target policy. This envisaged a first wave strike by 1,500 bombers against 800 targets. The Chiefs of Staff then approved the dual targeting policy for the V-Force – a unilateral strike against Soviet cities and a combined offensive with SAC directed against a mix of urban and military targets. Twigge and Scott (2014): "Later approved by the Defence

[61] Ibid, "How did Bomber Command prepare for war?"; amongst documents/text provided: 25/6/20.
[62] Dick Fuller, Valiant Co-Pilot, 49 Squadron (1959-63), RAF Wittering/RAF Marham; amongst documents/text provided: 29/10/20.
[63] Nick Dennis, Vulcan Co-Pilot, 12 Squadron, RAF Coningsby/RAF Cottesmore; Captain, 44 (Rhodesia) Squadron; interviewed: 30/5/18.
[64] Group Captain Roger Dunsford, Vulcan Co-Pilot and Captain; amongst documents/text provided: 20/4/20.

Committee, these recommendations formed the basis of Bomber Command's Emergency War Plan, which came into operation on October 1 1958."[65]

As for assessing possible V-Force outcomes, the late 1950s and 1960s produced mixed evidence. Positive signals included "Skyshield", large-scale annual exercises (1960-61) involving NORAD (now North American Aerospace Defence Command)/SAC and testing defences against Soviet air attack. The results showed North American air defences in a poor light, with only some 25% of attackers intercepted. During these exercises, *all air traffic*, from the Arctic Circle to Mexico, was grounded for up to 12 hours. Around 6,000 sorties were flown by the USAF, RCAF and RAF, with simulated attacks on New York, Chicago, San Diego, Los Angeles, Washington DC and other large cities. The September 10 1960 Skyshield included an attack by eight Vulcans, four from Scotland and four from Bermuda. One Vulcan was intercepted by an F-101 Voodoo at 56,000 ft over Goose Bay. The other seven, however, reached their targets and returned unscathed. Their strong performance was put down to ECM and the Vulcan's extreme manoeuvrability at high altitude.[66]

All V-bomber crews knew they stood more chance at night, in filthy weather. Vulcan Pilot Edward Jarron acknowledged that a bright sunny day would have been a big disadvantage: "In those conditions, perhaps just a handful would have got through, but it would have been a very different story at night – well over half would have dropped their weapons."[67] Vulcan Captain John Huggins recalls the element of self-belief: "The bottom line was that we were confident that a proportion of the V-force would get through and destroy their targets. All National Plan targets were Soviet cities. The SACEUR targets tended to be key military assets that should already have been hit by missiles … Our crew targets under the latter plan included Murmansk and Riga."[68]

Vulcan crews put up another strong performance during the October 14 1961 Skyshield. Four 27 Squadron aircraft made their attacks from Bermuda, while four 83 Squadron Vulcans penetrated defended airspace after flying in from Lossiemouth. The northern force attacked in a stream and reported only one radar contact. Overall, nearly half the low level attackers went

[65] Twigge and Scott, *Planning Armageddon,* 70-71.
[66] Wikipedia, 2021, "Operation Sky Shield". Last modified July 10 2021. https://en.wikipedia.org/wiki/Operation_Sky_Shield
[67] Air Commodore Edward Jarron, Vulcan Pilot, Assistant Air Attaché in Moscow during the mid-1970s, Station Commander, RAF Cranwell (1989-90), Chief of Special Weapons, SHAPE (1992); interviewed: 23/7/19.
[68] John Huggins, Vulcan Captain; documents/text provided: 26/10/20.

undetected. Of those initially detected, 40% escaped tracking radar through evasive tactics. No more than one in four would have been intercepted.[69]

Less positive results were recorded in a British exercise, Matador 2, flown on September 29 1962. This involved four simulated raids on the UK, involving 64 aircraft. The aim was to test the serviceability and effectiveness of the V-bombers' Red Shrimp jammers and Red Steer and Blue Saga warners, gather information on the use of Window (chaff) and assess the effectiveness of radar and communications jamming. Reporting on the outcome in February 1963, Bomber Command Chief Research Officer Tom Kerr said Fighter Command intercepted 39 of 64 bombers at least once, mirroring outcomes in earlier exercises. The 73 participating fighters achieved 92 intercepts. SAM sites claimed to have engaged 31 of the 47 bombers entering the missile zones.[70]

In the ultimate sense, operational effectiveness means the ability to deliver the UK's core retaliatory threat, HOWEVER THAT THREAT IS DEFINED. Appropriate targeting is the central component of UK retaliation and that requires a maximised deterrent threat and optimised destructive potential from a small number of megaton class weapons. In this chapter, the significant changes in the definition of unacceptable damage are charted. There was a marked decrease in the number of countervalue (city) targets, but retention of the very largest urban targets, with V-Force deterrence resting on the ability to do damage sufficiently severe to undermine the balance between the superpowers. The fundamental requirement, in this context, is the potential to make successful attacks on Moscow and Leningrad (the targets for the QRA force, at readiness to provide the UK's minimum retaliatory response). A degree of ruthlessness is evident in the British planning, in order to maximise the chances of successful attacks on the first and second cities. The planners' first priority was to ensure continuity of threat until the arrival of Polaris.

[69] Wikipedia, 2021, "Operation Sky Shield". Last modified July 10 2021. https://en.wikipedia.org/wiki/Operation_Sky_Shield

[70] AIR 14/4333, Bomber Command, Operational Research Branch, Memorandum No. 264, "Exercise Matador 2", February 8 1963.

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VULNERABILITIES ON THE GROUND: THE THREAT

This is the first of several chapters addressing MBF exposure to destruction on the ground by bombers and, subsequently, IRBMs. Soviet missiles fired on low trajectories offered very little warning and had the potential to wipe out the V-Force. Given that Ground Alert was the only viable posture for the MBF, this chapter considers how Bomber Command developed training, exercise and transition to war regimes which would allow a proportion of the force to survive a pre-emptive missile strike and deliver a retaliatory attack. Bomber Command responses to the growing missile threat are documented, to provide an overview of how they were shaped by very short time-frames for warning and reaction. Dispersal was an important element of Ground Alert, but its organisation and exercise was subject to certain constraints, not least the avoidance of flights with live weapons.

Defining the threat

Could the V-Force be pre-empted? Low trajectory Soviet IRBMs began to deploy some years before BMEWS Fylingdales commenced operation. Depending on the attack mode, Fylingdales might give only 3.5 to 4.5 minutes' warning. Yet the V-Force adopted 15-minute Readiness, claiming that the Soviets would launch for simultaneous burst in the USA and UK – thus granting Britain the significantly longer warning enjoyed by the Americans as a matter of geography. British planners initially assumed one missile per MBF airfield, with the possibility of others aimed to catch those V-bombers immediately surviving a war scramble. Subsequent estimates allowed for four weapons per airfield. Assessments of V-Force ability to survive a Soviet missile strike varied from a remarkably optimistic forecast of over 90%, made in 1971, to the more realistic 26% or less in a 1962 study. Even the latter was based on an unlikely combination of favourable circumstances, with *all crews* at RS05 (Cockpit Readiness) when the order to scramble came. The fundamental problem of vulnerability on the ground may be expressed in simple terms: *any attack scenario would be a surprise*, in that bombers can be scrambled only on detection and confirmation of incoming missiles.

Reducing exposure on the ground

Dispersal is the obvious counter to vulnerability on the ground. Small dispersed flights, two or four aircraft per airfield, would reduce vulnerability and give more aircraft the chance to get off before the missiles burst. At the same time, more radical solutions were explored, including SAC-style Airborne Alert. This would put QRA aircraft (representing a minimum retaliatory capability) into the air, rather than remaining exposed on the ground. Andrew Brookes (1982) noted that "SAC kept Airborne Alert aircraft up for 24 hours, from midday to midday, with two tank-ups in between." Each bomber was given 25 targets, all at different ranges from base, the idea being that the crew worked through the targets as their fuel reserves dwindled, until they refuelled and then they moved back to the furthest again.[1]

Airborne Alert was inappropriate for the V-Force: there were insufficient bombers and tankers and the aircraft lacked room to carry extra crew. V-bombers would have to rotate every six hours. Andrew Brookes referred to an experiment at Waddington, which involved flying 64 5½ hour Vulcan sorties round the clock during a 14-day exercise, "but this imposed such a strain on the station that the Airborne Alert plan died with Skybolt."[2] Yet, Airborne Alert looked so attractive, at first glance, that it was studied repeatedly – and repeatedly ruled out – over the years. A second radical survival option was dispersal to remote overseas airfields. Unfortunately, all remote locations required flight refuelling to provide adequate target cover and there were insufficient tankers. This left only one option: enhanced Ground Alert on UK airfields, with measures to compress the time required to scramble.

The Soviet manned bomber threat

A 1955 ACAS briefing put Soviet medium bomber strength at 81 jets and 853 piston-engined aircraft.[3] The fast-growing Soviet LRAF had been watched with concern for some time. A September 1953 briefing for the CAS referred to a JIC report on a SACEUR study concluding that no more than three days' warning of attack could be expected. In contrast, the British Intelligence appreciation was that "30 days' warning should be received if the Soviet Union were to launch a full-scale attack."[4]

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[1] Wing Commander Andrew Brookes, *V-Force: a history of Britain's airborne deterrent* (London: Jane's, 1982), 143.
[2] Ibid.
[3] AIR 8/1934, "Likely Soviet courses of action up to January 1 1957", ACAS briefing for Defence Committee meeting, October 28 1955, DC (55), 46.
[4] AIR 8/1858, "Warning of attack", briefing note for the CAS, September 30 1953, COS 1588/15/9/53.

By January 1955, however, a new realism prevailed. In a note, ACAS got to grips with the terminology: “In the past, the term ‘warning of attack’ has been rather loosely used and one was led to believe that by observing various ‘indicators’ … we could expect, say, three or four weeks’ warning of attack.” The new paper differentiated between “preparations for war” and “warning of actual attack”. It added: “… ‘warning of actual attack’ would probably amount to no more than a very short time made available from the detection of enemy aircraft on Allied radar screens. Under adverse conditions, this time could be as short as 20 minutes.” It also made the vital point: “Intelligence does not expect to be able to give the date or hour of attack.”[5]

MBF main bases were defended by SAMs and fighters. When it was recognised that sufficient attackers would still get through to destroy Britain, the UK Air Defence role switched to a deterrent function – protection of MBF bases. Later, planners recognised that hostilities could commence with a period of conventional warfare. This should have raised questions about how to defend the widely dispersed V-Force, as point defences were centred on MBF main bases. Duncan Sandys’ April 1957 Defence White Paper placed emphasis on missiles; the fighter force was to be much reduced. There was a view that fighter and SAGW defences would become an irrelevance as the strategic missile threat matured. In 1958, however, it was accepted that fighters were still needed to confront the Soviet bomber threat, for as long as that continued. An undated note for the CAS envisaged SAGW units defending the deterrent increasing from 23 in 1961 to 58 in 1965, whereas the fighter force would reduce from 19 to 13 squadrons over that period. The note considered 13 fighter squadrons “to be the minimum required to give validity to defence of the deterrent, as a complement to the planned SAGW defences.”[6]

An attack on the airfields by Soviet bombers was envisaged in three zones over a front 200 miles in length: “To produce a realistic contribution towards the deterrent, the fighter force should be able to show a potential capability to eliminate or repel between one quarter and one third of this threat before SAGW defences come into action. Anything less than this capability would not be a realistic deterrent as seen through Russian eyes.” Even assuming the highest estimates of fighter lethality, this would require the capability to put at least 40 fighters into engagement with the enemy

[5] AIR 8/1858, “Warning of attack”, ACAS briefing note for the CAS, January 4 1955.
[6] AIR 8/1942, “Future metropolitan fighter force.”

in each zone. This would require four squadrons (each of 12 aircraft) covering each of the three zones. Naturally, a fully dispersed V-Force would be harder to defend. The note acknowledged that only one squadron, plus OCU aircraft, would be available to protect dispersal bases in Scotland.[7]

Spending on fighter defence always triggered challenge. Macmillan was a sceptic about fighters and big cuts came in Sandys' April 1957 Defence White Paper, which redefined the fighter role as defence of MBF airfields.[8] While opposed by Secretary for Air George Ward, the cuts in the fighter force were confirmed in the 1958 White Paper.[9]

Some of Macmillan's doubts were shared by the Air Staff. In a June 1956 paper, Air Chief Marshal Sir Ronald Ivelaw-Chapman, VCAS, acknowledged that UK air defence "would be incapable of preventing widespread devastation of the United Kingdom." He also argued, however, that UK air defence was an "essential part" of the deterrent.[10] Sandys' 1957 White Paper echoed these themes: there was no means of providing adequate protection from nuclear weapons – some enemy bombers would inevitably get through and, even if only a dozen, they would "inflict widespread devastation." This is an interesting reflection, as this very principle would apply, in equal measure, to a small group of surviving V-bombers attempting to retaliate.

The White Paper recognised the significance of air defence to deterrence: "It is essential that a would-be aggressor should not be allowed to think he could readily knock out the bomber bases in Britain before their aircraft could take off from them. The defence of the bomber airfields is therefore an essential part of the deterrent and is a feasible task." Nevertheless, the fighter force shrank dramatically as the missile threat grew. Between 1956 and 1958, Fighter Command's strength was cut from around 600 aircraft to 300, falling further, to 272, in 1960, then to just 140 by 1962."[11]

[7] Ibid.
[8] Richard Lamb, *The Macmillan Years*, *1957-1963* (London: John Murray, 1995), 282-283.
[9] Ibid, 284.
[10] AIR 6/124, "Future size and shape of the Royal Air Force", note from VCAS to the Air Council Standing Committee, June 7 1956, SC (56) 16.
[11] Michael Armitage, *The Royal Air Force: an illustrated history* (London: Arms and Armour, 1993), 204.

As for SAGW defences (and regardless of earlier projections), a 1963 response to a USAF request for information on RAF QRA status listed 10 SAM squadrons, each with 32 Bloodhound 1 weapons (10% at 10 minutes' alert and 80% at two hours).[12]

Missiles and warnings

In the late 1950s a seven-day strategic warning period was assumed, allowing Bomber Command time to come to Readiness and achieve maximum generation of aircraft (estimated maximum serviceability: 85-90%). The assumed minimum tactical warning was 40 minutes (based on attack by subsonic bombers). Once alerted, the V-Force would be held at 40 minutes – to be sustained for up to 30 days (at 15 minutes, up to seven days). A 1957 report on Bomber Command's ability to come to alert summarised these early views on Readiness, based on assumptions that:

- Aircraft are held fully-fuelled and ready for starting immediately, with bombs in the bomb-bay, maintained for a strictly limited period of "great national emergency" – a maximum of one month.
- Aircrews maintain a three-watch system: first watch at the aircraft or in a crewroom not more than five minutes away; second watch at meals or recreation but able to reach their cockpits fully-dressed in 15 minutes; and third watch sleeping but also able to reach cockpits in 15 minutes. Allowing 15 minutes for checks, starting engines and taxiing, the aircraft should be off the ground in 20-30 minutes.[13]

Soviet missiles changed everything. As early as 1955, the JIC included the destruction of MBF airfields as "one of the enemy's aims within the United Kingdom."[14] In his June 1956 note, Sir Ronald Ivelaw-Chapman warned: "What would be significant would be if, while we were still reliant upon bombers, the Russians were able to knock them out by ballistic missiles at their airfields before they could take off."[15]

Early warning of missile attack became essential and this led to the construction of BMEWS at Fylingdales Moor, Yorkshire. Operational from September 1963, it joined

[12] AIR 2/16435, "USAF request for information of RAF QRA status", loose minute from Wing Commander D.G. Evans, Air Plans 2, to D. of Ops. (B&R) and others, April 5 1963.
[13] AIR 2/13717, "Study of the present ability of Bomber Command to come to an alert state", D.D. Ops. (B), October 28 1957.
[14] Richards, "Time is no longer our ally," 39-40; CAB 21/4035, JPG/55/1, JIC (55) 12, January 4 1955.
[15] AIR 6/124, "Future size and shape of the Royal Air Force", June 7 1956, SC (56) 16.

BMEWS stations at Thule, Greenland, and Clear, Alaska. Squadron Leader Michael Hely spent three years as Engineering Staff Officer responsible for Fylingdales:

> This site's function was governed by the Joint Operations Plan, which set out the operational priorities. While Fylingdales did supplement Thule and Clear, in that it could detect ICBMs bound for the USA, its *primary* role was to provide a warning of an IRBM attack on the UK… Our very clear priority was to identify UK-bound IRBMs …[16]

Before Fylingdales began operation, Bomber Command received early warning input from the Americans. Bomber Command Headquarters, High Wycombe, was linked to NORAD, Colorado Springs, allowing the British to share SAC early warning information from 1960.[17] In April 1961, Bomber Command's Operational Research Branch reported on estimates of minimum warning times expected from Fylingdales when in operation. The threats considered were missiles with ranges of 650, 1,000 and 1,500 miles (assuming fired to maximum range in optimum trajectories or in low trajectories with a 15 deg. re-entry angle). The shortest warning time from missiles fired from Russia was "approximately 4.2 minutes at Fylingdales Moor when a 1,000 miles missile is fired on a low trajectory over 650 miles range. This would give Kent and areas of Essex, Suffolk and Norfolk just under four minutes."[18] The "four-minute warning" took firm root in the public mind.

The US early warning alarm consisted of:

- Alarm Level 3: one double scan of a tracked threat object in five minutes, two in 15 minutes and three in 25 minutes.
- Alarm Level 2: two in five minutes, three in 15 minutes and six in 25 minutes.
- Alarm Level 1: three in five minutes, six in 15 minutes and nine in 25 minutes.[19]

The US Alarm Level was displayed in the Bomber Command Operations Centre (BCOC). According to another ORB memorandum (No. 285, February 1964), probable false alarm rates due to environmental conditions at Thule/Clear were:

- Alarm Level 3: one in two years.

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[16] Squadron Leader Michael Hely, Engineering Staff Officer, BCAS (1960-62), "Afterthoughts", RAF Historical Society, *Journal 26* (2001): 105-112.
[17] Menaul, *Countdown*, 112.
[18] AIR 14/4305, Bomber Command, Operational Research Branch, Memorandum No. 222, "Calculations of the minimum warning times obtainable from the BMEWS, at Fylingdales Moor, of ballistic missile attacks on the United Kingdom," April 1961.
[19] AIR 14/4354, Bomber Command, Operational Research Branch, Memorandum No. 285, "BMEWS and the QRA force", February 1964.

- Alarm Level 2: one in 12 years.
- Alarm Level 1: one in 500 years.[20]

As for the probability of false alarms from technical faults/human error, the memorandum merely commented: "NORAD should be able to identify these quickly and pass this information rapidly via Fylingdales to BCOC."[21]

The three UK IRBM alarm levels, for obvious reasons, had different timescales:

- Alarm Level 3: one in two minutes, two in five minutes and three within 15 minutes.
- Alarm Level 2: two in two minutes, three in five minutes and four within 15 minutes.
- Alarm Level 1: three in two minutes, four in five minutes and five within 15 minutes.[22]

Memorandum No. 285 explained the process:

> If, for example, three target objects are tracked within two minutes, the Alarm Level will be raised through 3 and 2 to the higher Alarm Level of 1. After two minutes from the tracking of the first object, if no further threat objects have been tracked, the Alarm Level will fall to 2, after five minutes to Alarm Level 3 and after 15 minutes will disappear off the display. During this period, the number of objects which are assessed as a threat and have been tracked is displayed and will remain constant on the display until the predicted impact time has elapsed, although the Alarm Level starts to decrease after five minutes. The number of tracked events is extremely important to the C-in-C or his Deputy, as this is the only method of providing an immediate assessment of whether the Alarm Level 1 has only just been reached or whether a mass raid has been launched.[23]

On frequency of false alarms from Fylingdales due to technical fault and human error, the memorandum added that this will only ever be derived from experience: "If human error is the cause, there is an equal likelihood of any of the three Alarm Levels being raised."[24]

Quick Reaction Alert

SACEUR-assigned Valiants were QRA pioneers; one aircraft per squadron was held fuelled, bombed-up and ready to go at 15 minutes, round the clock. Nav/Radar Tony Wright described the scene: "… our Valiants were parked on pans within a wired-off

[20] Ibid.
[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] Ibid.

compound and guarded by both RAF and American police, as our weapons were under dual control. Our accommodation was adjacent, but outside the protected area."[25] Dick Fuller, a Valiant Co-Pilot, recalled how life gradually became more serious for V-Force crews: "At Marham, we always had three aircraft with live weapons on QRA for 48 hours at a time. They were manned by crews from 49, 217 and 138 squadrons. During QRA we went from 15 minutes' Readiness to five minutes. We sat in the aircraft, connected by the link to Bomber Command Headquarters, High Wycombe. Five minutes' Readiness was called two or three times a week. It wasn't very pleasant to turn out at 2 am on a Winter morning, climb in and get ready to go."[26]

Valiant Pilot Tony Cottingham recalls QRA developing in stages:

> At first it was three hours' Readiness, which allowed married crew members to be on call at home by telephone… The response time soon became 15 minutes, 24 hours a day. When on duty, crews stayed together, whether in a Duty Room in the Operations Centre, or at the Officers' Mess … the car parked nearby, for a quick dash to the aircraft, which was parked on the nearest dispersal to the runway. Call-out was by means of a Tannoy message which began with a very loud-ringing phone bell.[27]

When the Valiants were grounded in January 1965, SACEUR lost his three squadrons of V-bombers – the Tactical Bombing Force (TBF). His argument for replacement with Vulcan 1/1A aircraft about to leave MBF service was rejected on grounds of cost, supported by a presenting case that SACEUR already had sufficiency of nuclear assets and that TBF's loss would not affect the viability of the deterrent. SACEUR was told that there would be no Vulcan TBF on March 26 1965.[28] He had valued Marham's Valiants as they were his only all-weather, blind-bombing assets. He also, of course, regretted the loss of 48 potential nuclear strikes - each TBF Valiant carried two American weapons.[29]

In January 1963 the main force QRA consisted of 11 Vulcans and Victors: Waddington (3), Honington (2), Cottesmore (2), Wittering (1), Coningsby (1) and Scampton (2). AOC-in-C Bomber Command wanted this QRA force increased to 17 bombers, from April 1 that year: Waddington (6), Honington (3), Cottesmore (3), Wittering (2), Coningsby (1) and Scampton (2). This would be followed by a further

[25] Tony Wright, Valiant/Vulcan Nav/Radar; interviewed: 26/3/19.
[26] Dick Fuller, Valiant Co-Pilot; amongst documents/text provided: 29/10/20.
[27] Tony Cottingham, Valiant Co-Pilot, 49 Squadron, RAF Wittering; Captain, 7 Squadron; interviewed: 8/2/18.
[28] Wynn, *RAF nuclear deterrent forces*, 467-497.
[29] Ibid, 363-367.

increase, to 20 QRA aircraft, by July 1, taking in aircraft from Blue Steel squadrons. The plan included a trial (at Waddington) of centralised flying and servicing. [30]

Given that a Soviet "bolt from the blue" attack was thought unlikely (and, perhaps, impossible to achieve), was there real value in continuous QRA? Would regularly exercised "Emergency QRA", as a 24/7 first response to heightened tension, have been a less debilitating and, ultimately, more appropriate posture? Here, Edward Jarron, a former Chief of Special Weapons at Supreme Headquarters, Allied Powers Europe (SHAPE), makes an interesting observation: "The most important point is that permanent QRA is a statement of resolve. It is a matter of nuclear signalling. That is of great importance."[31] Permanent QRA was also a response to American doubts about V-Force effectiveness. In 1962, SAC concluded it could count on only eight V-bombers being certainly operational.[32] Bomber Command's AOC-in-C, Air Marshal Sir Kenneth Cross, wrote to the CAS, Sir Thomas Pike, in November 1962, outlining plans for a near doubling of the QRA force to compensate, to some degree, for the phase-out of Thor.[33] Cross sent a follow-up on January 10 1963: "Detailed studies have now been completed and from April 1 I propose increasing the QRA force to 17 Vulcans and Victors (plus the four Valiants of the SACEUR force), rising to 20 Vulcans and Victors by July 1, when the Blue Steel squadrons will be able to make their contribution. This plan will enable me to maintain approximately 20% of the force at permanent Readiness and will go some way to compensate for the rundown of Thor."[34]

These plans ran into trouble. They were put on ice pending clarification of the position regarding main force assignment to NATO, post-Nassau. In a June 1963 note to the CAS (after the NATO assignment had clarified), VCAS took the view that they should stay on ice; there was no change to existing QRA arrangements. There was history surrounding this reluctance to expand QRA. In December 1961 QRA was about to be introduced at one aircraft per squadron. However, the AOC-in-C proposed expanding QRA to two aircraft per squadron (increasing the QRA force to 25% of V-Force strength by end-1962). CAS took the view that this had "wide implications" and that

[30] AIR 2/16435, "Notes on Bomber Command plan to meet increased QRA commitment", Ops. B.2, draft, January 17 1963.
[31] Edward Jarron, Vulcan Pilot, Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[32] Baylis, *Ambiguity and deterrence*, 349.
[33] Wynn, *RAF nuclear deterrent forces,* 335.
[34] AIR 8/2369, "Increased Readiness - Bomber Command", letter from AOC-in-C, Air Marshal Sir Kenneth Cross, to CAS, Marshal of the Royal Air Force Sir Thomas G. Pike, January 10 1963.

consideration should be deferred.[35] Cross persisted, tabling a more modest proposal – going from 11 to 17 main force bombers (subsequently to 20 by July 1963). Once again, he failed to find support. Indeed, even existing QRA arrangements (one aircraft per squadron) prompted debate about, for example, the cost of a few extra RAF Police and discussion over whether one man could guard two aircraft loaded with live nuclear weapons (the aircraft requiring a minimum separation of 150 yards on dispersal). One idea was to use ground personnel as guards. The Inspector-General proposed schemes for saving police posts and went so far as to recommend "radically reduced" policing of Thor sites. This, however, was subject to formal Anglo-American agreement; visitors from the Pentagon told the Air Ministry that this could not be re-negotiated.[36]

BMEWS and QRA

The relationship between BMEWS and V-bomber QRA was explored in a Bomber Command memorandum of February 1964. This explained the basis for QRA Readiness at 15 minutes, but made no attempt to justify underlying assumptions. The crux of the study is the timing of Soviet missile launch in a "bolt from the blue" attack, together with, inter alia, the conditions under which scramble should be ordered – to minimise the chance of responding to a false alarm while giving some aircraft a possibility of escape.[37]

Control procedures for QRA were founded on the view that the USSR would launch for "simultaneous impact" in the USA and the UK, providing the UK with 15-20 minutes warning. In other words, missiles with US targets would launch first. The UK/Western Europe would then benefit from the longer American warning: "To meet this situation the QRA force is held at 15 minutes' Readiness. The force generally reacts much more quickly than this and, therefore, some aircraft would escape from an attack in which the IRB and ICB missiles were launched simultaneously."[38] The memorandum gave no estimate of what "some aircraft" meant. No attempt was made to explain why the Russians should offer the British as much warning as the Americans, by adopting simultaneous impact attack – the basis of RS15 – and sacrificing the benefits of simultaneous launch in the West European context.

[35] AIR 8/2369, Air Council, conclusions of meeting 23 (61), December 7 1961, Secret Annex.
[36] AIR 8/2369, "Guard duties – Bomber Command Stations", November 28 1961.
[37] AIR 14/4354, Bomber Command, Operational Research Branch, Memorandum No. 285, "BMEWS and the QRA force", February 1964.
[38] Ibid.

How much time was required to carry out final actions and scramble? The memorandum stated that the best recorded response of an RS15 QRA crew to an RS02 alert (start engines) was four minutes 25 seconds (average: eight minutes six seconds) in Autumn 1962 and two minutes 25 seconds (average: six minutes 24 seconds) in Autumn 1963 – one of only four occasions when times of less than three minutes were achieved (crew in the cockpit doing checks, in daylight hours).[39] These figures suggest that, given simultaneous launch rather than simultaneous burst, "some aircraft", in reality, could mean just one or two – given that only 11 were on QRA and only the most fortunate (at Cockpit Readiness) would be able to respond instantly to RS02/scramble and get off quickly enough. In the case of simultaneous missile launch, with BMEWS providing only minimal warning, there was a real possibility (given no QRA aircraft at RS05) that there would be *no survivors* to begin the North Sea crossing.

This memorandum acknowledged that simultaneous launch meant a low probability of escape, but did not dwell on unpleasantries. Instead, it focused on simultaneous burst – the only scenario providing enough warning for more of the 11-strong QRA force to get away. Sheltering under the assumption that the Russians would defer launch against the UK for some minutes after launch against the USA, to achieve simultaneous burst, this report continues:

> …it can be seen that if RS02 is ordered as soon as Alarm Level 3 arises, it will take the fastest crew 2½ minutes to reach the end of the runway for take-off. Crews take three minutes or more to reach the end of the runway on 99% of occasions. Clearly, this time can be used for direct consultation between Bomber Command Operations Centre and the Operations Room at Fylingdales, to establish whether the alarm is real or false. If, during this period, Alarm Level 1 has been reached and Fylingdales confirms that the alarm is real, then the scramble order can be given (three minutes after the initiation of Alarm Level 3) with a negligible loss in the reaction time of the force.[40]

The problem, of course, is that these times would mean almost certain destruction in a simultaneous launch/low trajectory attack unless aircraft were at RS05, primed for immediate RS02. Verification could come too late in a simultaneous launch/minimum warning case. Should the Soviets launch simultaneously against the UK and USA, Bomber Command would get the minimum warning – around four minutes. Against this background it is easy to understand why planners embraced simultaneous

[39] Ibid.
[40] Ibid.

burst/RS15. According to the memorandum, a simultaneous burst attack would be detected 7½ to 12½ minutes before detection of the IRBM attack on the UK.[41] This would provide up to 16-17 minutes (perhaps more, allowing for a spread of impact times) to man cockpits, start engines, taxi, take-off and achieve escape distance. RS15 was inappropriate for response to a simultaneous launch attack, but did at least allow the V-Force a daily operating environment with sufficient space for routine functioning, although force deployment and behaviour in a close approach to war would have been very different.

The ORB noted the logic of associating Anglo-American alarm levels, in the context of "deciding the criteria from which the scramble order will be given. This increases the confidence that the scramble order will not be given on a false alarm …" That said, it was recognised as essential that a scramble could be ordered on the UK Alarm Level alone, due to a possible attack on the UK alone or the severing of Fylingdales/NORAD communications. Two additional pieces of information were needed to help ensure no scramble on a false alarm: the number of threat objects tracked (a real attack would involve numbers of threat objects far above Alarm Level values within the first two minutes) and a check with Fylingdales Operations, to ensure a false alarm is discounted.[42]

The Memorandum added that the response would always allow enough time for verification:

> This will take a short time, but there is clear evidence from the practice alerts of the QRA force that three minutes are available from the order to Readiness 02 before this state is achieved by the fastest crews. From the current IRBM threat, some 7½ minutes warning of attack is expected. In order to retain a probability of escape, it is essential that the order to scramble be given four minutes before the predicted time of impact. This allows up to three minutes from the first alarm to the time that the scramble order must be given.[43]

Then came a brief, somewhat reluctant acknowledgement of other, more negative possibilities:

> When the QRA force was introduced, the 15-minute Readiness State was fixed so that it had a high probability of escaping from an attack which involved simultaneous impact of missiles on the USA and UK. The EDOM exercise has

[41] Ibid.
[42] Ibid.
[43] Ibid.

> clearly demonstrated that this can be achieved in practice. For other types of attack, the escape probabilities are relatively small.[44]

The Memorandum sets out QRA scramble criteria: USA Alarm Level 1, associated with a UK Alarm Level 3 or higher, in the case of an attack involving simultaneous impact. "The attack on the USA is detected 7½ to 12½ minutes before the IRBM attack on the UK." This is the key assumption. A second is that most QRA aircraft would have reached RS02 (ie. ready for SIMSTART) before the attack on the UK is detected (average time from RS15 to RS02: around seven minutes). There would be as much as seven minutes plus available to escape from first weapon detonation and "aircraft have a high probability of escape." The picture is very different for simultaneous launch/detection of missiles fired against the UK and USA. Here, the scramble criterion put forward is UK Alarm Level 1 associated with USA Alarm Level 3 or higher, or associated with a break in Fylingdales/NORAD communication: "Attack detected approximately simultaneously, QRA force will have seven minutes plus from Alarm Level 3. As the QRA force takes, on average, seven minutes to reach Readiness State 02, the probability of escape is relatively small."[45]

Other cases are an attack on the UK alone, or missiles launched against the UK before those against the USA. Here, the scramble criterion was UK Alarm Level 1, with "time to impact" reduced to four minutes:

> The QRA force will have approximately seven minutes' warning. As the minimum time to reach Readiness State 02 is three minutes, this time can be used to establish the validity of the alarm. If the Intelligence data on missile trajectories is correct, then this exactly corresponds with the displayed time to impact decreasing to four minutes. The probability of escape is relatively small.[46]

If the presenting basis of RS15 is correct and the attack is for simultaneous impact, QRA aircraft have relatively good prospects for escape, given an additional 7½ to 12½ minutes of "American warning" (although one needs to construct a case for the Soviets granting the UK/Western Europe this period of grace). In the event of simultaneous launch, or attack on the UK alone, the escape probability is low. The memorandum was certainly correct in emphasising that the "present procedure of bringing the crews to Readiness State 02 on the receipt of any USA or UK Alarm

[44] Ibid.
[45] Ibid.
[46] Ibid.

Level is essential to keep the overall reaction time of the force to a minimum."[47] No mention is made of the threat from missile-firing submarines positioned off the UK west coast (Fylingdales' fixed aerials faced east). Obvious priority targets for SLBMs would be MBF dispersal airfields in the north and west. There was no Readiness allowance for this threat. As Richard Moore (2010) wrote, BMEWS "could not be expected to detect submarine-launched missiles fired towards the UK from the west." [48] Furthermore, an initial mass SLBM launch by Soviet submarines close to the US seaboards would put many American targets in a similar position to their UK counterparts. In this context, simultaneous burst might be attractive, should flight times for a substantial weight of attack on Continental US and European targets be approximately equal. Indeed, in this scenario, simultaneous launch achieves near simultaneous burst.

Was 24/7 QRA the right approach?

V-Force QRA was always open to challenge. There were many deployment options. QRA bombers could have been routinely distributed at random across dispersal airfields (perhaps more frequently to those with the longest warning times). One QRA bomber per airfield would maximise the chance of escaping a pre-emptive strike. The organisation, effort and cost required to introduce such a regime, almost certainly, would have been regarded as prohibitive. It would have required regular flying with live weapons loaded. Another option would have been occasional flying with live weapons to dispersal airfields. In October 1963 AOC-in-C Sir John Grandy proposed flying aircraft carrying fully fuelled Blue Steels, fitted with live warheads, from main bases to dispersals, to test the stand-off bomb's ability to withstand war emergency conditions. According to Wing Targeting Officer Roy Brocklebank: "We never practised or considered converting an Exercise Mick into a Micky Finn…we never considered the full fuel dispersal case." Interestingly Brocklebank noted that Hawker Siddeley did eventually clear the Vulcan to land at maximum take-off weight.[49] Fully fuelled dispersal was feasible.

V-bombers never flew over the UK with live nuclear weapons, a significant restriction on dispersal exercises and QRA. No evidence was found of plans for enhancing V-Force Ground Alert through routine rotation of the QRA force, as single aircraft, to dispersal airfields (with, perhaps, a bias towards airfields in the north and west

[47] Ibid.
[48] Moore, *Nuclear illusion, nuclear reality*, 224.
[49] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 21/4/20.

offering additional warning of incoming low trajectory missiles from the east). Nevertheless, the adoption of an "ultra ready" Alert Condition 1 with up to 30% of the V-Force manned at RS05, 24/7, as early as 1961 suggests that aircraft, manned by the most experienced crews and with big city targets, could have been dispersed to geographically favoured airfields in conditions of imminent war threat. The barriers to enhanced dispersal exercises and "rehearsal" deployment for a severe crisis would have been additional cost and effort, requiring, for example, each dispersal QRA duty to have been immediately preceded by a dispersal flight and regeneration (fully fuelled and armed), together with additional crews positioned to rotate RSO5 QRA duty periods.

In the absence of single aircraft dispersed QRA (fully fuelled and armed), a more palatable option might have been the construction of single weapon stores at some dispersal airfields (with priority for those airfields in the north and west), linked to a requirement for a proportion of bombers coming off QRA to make immediate post-QRA flights to those airfields, so allowing the regular testing of capabilities for reception and regeneration of these weapon systems to combat status. At the same time, a network of single weapon stores would have raised security as well as cost concerns. The prompt dispersal of QRA bombers (one aircraft per dispersal airfield, or more in favourable locations) at a time of grave crisis would, in effect, have been part of a wider "trickle dispersal" process. Looking back, Roy Brocklebank felt that Bomber Command "should perhaps have considered rotating crews at RS05…dispersing with full fuel loads and weapons capable of use."[50]

In the event, even the fundamental concept of permanent QRA had to be defended. ACAS (Ops.) called a briefing on December 17 1963 concerning QRA and SACEUR's requirements. There were moves afoot to relax 15-minute Readiness for tactical strike aircraft. A note from D. Air Plans' office, circulated before the meeting, asked, *inter alia*, a blunt question:

> The basis of our case against SACEUR's present QRA requirement is the current Intelligence assessment of the Soviet Bloc threat to NATO. A bolt from the blue attack by Russia is now considered to be highly unlikely. On the other hand, in the unlikely event of a surprise nuclear attack being launched by the Soviet Bloc, will the 15 minutes QRA state ensure the survival of a portion of our strike and reconnaissance forces?[51]

[50] Ibid; email: 25/6/20.
[51] AIR 2/16435, "Quick Reaction Alert", Air Plans 2/TS. 1204, loose minute, Group Captain J.R.L. Blount, December 17 1963.

It continued in similar vein (with a rare degree of straight-talking):

> General Parker (Chief of Staff, SHAPE, 1963-69) has stated that there has been no change in the threat. This could be accepted if he refers to the numerical strength of Soviet Bloc forces. However, the likelihood of a large-scale surprise nuclear attack being launched against Europe is the factor that should determine our alert posture, rather than the size of the forces opposing us. **General Parker also stated that the 15 minutes Alert State was valid as it would be logical for the Russians to coordinate their attack for simultaneous arrival of their missiles in the United States and Europe, but this is only one point of view. The Soviets could adopt a simultaneous launch for all missiles, with the result that Europe could receive no warning and the Soviets would ensure the elimination of the nuclear strike forces based in Europe, although the USA would still receive 15 minutes' warning from BMEWS.**[52]

The Soviet option to strike a huge counterforce blow in Europe by going for simultaneous rather than staggered launch appears more logical than the hope that they would allow Western Europe's nuclear assets to avoid near total destruction on the ground. At the same time, the fact that the Continental USA's longer warning would be eroded by expanding Soviet SLBM capacity was ignored.

Round-the-clock permanent QRA, as a concept, was certainly not sacrosanct. The D. Air Plans put forward the case for *relaxing* QRA for tactical (as opposed to strategic) strike forces:

> We should attempt to get the SHAPE staff to agree to a re-examination of the present QRA and Readiness concept for our tactical forces… We should also attempt to convince them that we do not disagree with the possession of a capability to mount QRA and a high overall state of Readiness either at random or during a time of international tension. However, we do not consider that the maintenance of the present high alert states throughout the year permit the most effective and efficient employment of our present resources. Some relaxation in Readiness States outside times of tension could result in better flying rates and increased training. This could be achieved by avoiding the retention on the ground of four fully serviceable aircraft per NATO squadron … Possible alternatives to the present QRA requirement could be either a reduction in the numbers of aircraft held on permanent alert or, alternatively, a rotation of QRA between squadrons and bases. We should, therefore, endeavour to convince SHAPE that a more flexible alert posture should be adopted for our Tactical Air Forces and methods of achieving this should be devised.[53]

[52] Ibid.
[53] Ibid.

Life on QRA

Vulcan Captain Nick Dennis' crew attained Combat status with 12 Squadron on December 20 1963, three days after the ACAS (Ops.) QRA briefing:

> We started QRA and life became pretty restrictive. A QRA during the week lasted 24 hours, but 48 hours at the weekend. We would take over at 9am and hand-over at 9am. The Captains would exchange keys and Go-Bags at the aircraft. At Coningsby we slept in a wing of the Officers' Mess. Later, at Waddington, we were accommodated in a huge, black-painted Nissen Hut. Most of the time on QRA was boring – it was quite a chore and added a lot of pressure to family life. The crew also took part in overseas reinforcement exercises and so spent quite a lot of time away, when this is added to QRA. [54]

There were no profound thoughts about nuclear war:

> We were very young and, frankly, I thought it impossible that something so catastrophic could happen. Should such an event occur, there wouldn't be much left of civilisation as we knew it – West or East! Yet, any one of those QRA exercises could have been the real thing and we wouldn't have hesitated. We would have gone faster and lower than we had practiced and the training over Goose Bay had been very realistic. Had it come to the real thing, everything would have been done more aggressively.[55]

Nav/Radar "Woody" Fulena remembers Cottesmore's "very relaxed regime", given its nuclear-armed aircraft on permanent QRA: "Surprisingly, it was a very open place compared to the barbed wire enclosures around RAF stations that have been in existence since at least the late 1990s. I remember an occasion when some local schoolteachers turned up unannounced at the Mess Bar on a Friday evening. They just felt they'd like to join us and drove from Oakham to Cottesmore Guardroom and asked for the Mess! Things were very different then."[56] In 1965, Flight Lieutenant Phil Leckenby was Co-Pilot to the Commander of 44 (Rhodesia) Squadron. He recalled how new crews were introduced gradually to QRA: "This ensured that inexperienced crews were not saddled with such an onerous operational responsibility until they had acquired a firm foundation of tactical flying by day and night, competence in all modes of weapons delivery, *au fait* with electronic warfare and fully trained on the complexities of the mighty bomb."[57]

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[54] Nick Dennis, Vulcan Captain; interviewed: 30/5/18.
[55] Ibid.
[56] "Woody" Fulena, Nav/Radar, 35 Squadron, RAF Cottesmore/RAF Akrotiri; interviewed: 26/6/18.
[57] Alan White, *The King's thunderbolts: No. 44 (Rhodesia) Squadron, Royal Air Force: An operational record and Roll of Honour, 1917-1982* (Lincoln (UK): Tucann, 2007), 180.

By January 1965, the QRA force was fixed at 11 aircraft (one per squadron), reflecting a long-term frontline strength of 88.[58] V-bomber main bases organised QRA in their own way; approaches differed, as recorded in an October 1962 Bomber Command report. Scampton then had two aircraft on QRA for a week or a fortnight, to avoid too frequent weapon changes. The crews did 24-hour QRA (08.30 to 08.30) in rotation. Each crew was on QRA about every fifth day. During the day they were in the Operations Block or at the aircraft, moving to caravans near the Ops. Block at night. Each crew had its own car, parked outside the Ops. Block, with the nearest aircraft about 500 yards away. The taxi distance for the first aircraft was 1,700 yards. By day, if the crew were in the Ops. Block, the Go-Bag was kept in a safe in the Intelligence Room; the Captain had the key. If the crew left the Ops. Block, the Captain took the bag with him. By night, the Captain took the Go-Bag to his room. The ground crew worked a normal two-shift system but the late shift provided a handling party which stayed behind and slept at the QRA site. This report (issued only the day before the climax of the Cuban Crisis) noted: "Scampton believe that aircraft should ultimately go on ORPs and that flying clothes be stipulated for the crews by day." The Tannoy was used to announce alerts by day, with alarm bells sounded during night hours.[59]

Waddington held three aircraft on QRA for about a fortnight, with 11 crews doing 24-hour (09.00 to 09.00) QRA in rotation per squadron. By day, one aircrew officer (out of the three crews) remained at the QRA site while the others were in the Ops. Block or Simulator Block next door. At night, an officer slept at the QRA site; the others slept in caravans near the Ops. Block. Transport consisted of one car per crew and the taxi distance was around 500 yards. Go-Bags were kept in the aircraft. Groundcrew did a 24-hour QRA (08.00 to 08.00), staying at the QRA site by day and QRA caravans at night. Alert by day was by Tannoy and klaxons, with a system of coloured lights on poles in the QRA area. By night, the Operations Duty Sergeant warned the officer on duty, who had access to klaxon, bell or voice warning over the Tannoy. The klaxon at the aircrew caravans warned of a cockpit alert, with the bell signalling engine start and/or taxi.[60]

Phil Leckenby recorded his memories of Waddington's QRA:

[58] AIR 2/16435, D. of Ops. (B&R), from HQ Bomber Command to MoD Air, Subject: QRA (handwritten annotation), January 20 1965.
[59] AIR 14/4327, Bomber Command, Operational Research Branch, Memorandum No. 258, "The Quick Reaction Alert in Bomber Command", October 1962, Appendix A.
[60] Ibid, Appendix B.

> The QRA set-up at Waddington was located at the H-shaped, four aircraft Alpha Dispersal, on the north-western side of the airfield … A short distance away from the dispersal was a slightly shabby collection of Nissen Huts providing accommodation for crews on QRA. They contained rudimentary dormitories with curtains affording basic privacy, an Operations Room equipped with an array of telephones and an intercom known appropriately as the "Bomber Box", a lounge area and a games room equipped with snooker and table tennis tables. The QRA hut complex was not quite close enough to the aircraft for rapid access on foot, so each squadron had its own QRA vehicle in which they raced to their aircraft whenever the Bomber Controller raised the Alert State from RS15 to RS05 or higher. A service vehicle, often of humble origins, provided transport for a Vulcan crew to its nuclear-armed aircraft.[61]

A 44 Squadron Nav/Radar, Squadron Leader Hickmore, remembered inter-squadron rivalry, to see who could get four aircraft aloft in the fastest time: "It was a hair-raising business. I believe the 44 Squadron time was one minute 40 seconds, but at the cost of a Crew Chief with a broken leg, as he was blown off the pan by the force of the jetwash. The record was one minute 27 seconds but it was a dangerous operation, particularly for the fourth aircraft, which would struggle to get airborne against the turbulence created by the aircraft ahead."[62]

During his first QRA ground duty at Waddington, Cliff Doe was introduced to Yellow Sun 2: "It was an enormous bomb and didn't leave much room in the bomb-bay. We couldn't work around it and had to open the bomb-doors to reach and check the hydraulic reservoir levels." In this Crew Chief's experience, groundcrew had little contact with aircrew: "They were on the domestic side of the airfield … The groundcrew were on Charlie Dispersal, with the main runway separating us."[63]

Experiments aimed at improving the efficiency of servicing and technical support were less than successful. In March 1964, MBF Squadrons changed from squadron servicing to centralised servicing. Cliff Doe describes the ensuing muddle:

> At Waddington everyone had to report to Delta and Echo dispersals, from where we were to be managed. It was absolute chaos when we arrived. The only people I knew were the ones with whom I worked on 101 Squadron. It was obvious that there were far too many chiefs. I spent four days in this chaos. Then one of the Warrant Officers came into the Crew Room and said: "I'm afraid no-one's given much thought to the manning of QRA. Until we get this mess sorted out, I want volunteers to work on QRA for the next three months". By

[61] White, *The King's thunderbolts,* 180.
[62] Ibid, 183.
[63] Cliff Doe, Vulcan Crew Chief, 35 Squadron, RAF Scampton; interviewed: 25/3/19.

> then I'd had enough, so I put my hand up. I knew what QRA was like, but I just wanted to get away.[64]

QRA offered the disciplined routine that was lost for a period in the switch to centralised servicing:

> When on QRA duties, all trades carried out their daily checks – virtually a before-flight servicing – every morning. If a practice alert went as far as engine starts and sometimes with the aircraft taxiing down the runway to simulate the real thing, a further inspection and fuel top-up would be required. We had four-bed caravans on the dispersal and there was a central Crew Room right next to the dispersal pans… The Vulcans were parked on pans at the end of each leg of an H formation. The QRA operated a two-shift system consisting of 48 hours per shift, then 48 hours off, followed by 72 hours on or off at weekends.[65]

Bomber Command's October 1962 QRA report noted that RAF Cottesmore held two aircraft on QRA for two to three weeks, parked within a barbed wire enclosure. Initially, the two Cottesmore squadrons had distinct, squadron-based QRA arrangements. There were six QRA crews at this time on 10 Squadron and three crews shared a week, doing two, two and three days in turn, changing over at 09.00 on the Monday, Wednesday and Friday (for a three-day weekend). There were eight effective crews on XV Squadron, with two crews sharing a week, doing three days and four days (changing at 09.00 on Monday and Friday). This changed from October 1 1962, when XV Squadron began operating as 10 Squadron. During the day crews remained together and were free to move around the base. At night, they slept in huts 50 yards from the Ops. Block.[66] Nav/Radar Roy Brocklebank describes the layout at Cottesmore: "The Mess was perhaps 200 yards from Ops. There was a wooden hut complex of three huts plus ablutions about 100 yards from the Mess, in the front and towards the Ops. Block, forming a triangle. When the Vulcan Wing moved to Cottesmore, the first two huts were used as Mess accommodation and the QRA crews took over nine bedrooms in the main Mess. In other words, QRA denied nine Mess members a room in the main Mess."[67]

There was a car for each crew, parked at night at the Mess, 100 yards away. It was the Co-Pilot's job to fetch it, drive to the Ops. Block and pick up the rest of the crew. There was a plan to provide garages nearer the sleeping quarters. The distance to

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[64] Ibid.
[65] Ibid.
[66] AIR 14/4327, Bomber Command, Operational Research Branch, Memorandum No. 258, "The Quick Reaction Alert in Bomber Command", October 1962, Appendix C.
[67] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 5/4/20.

the aircraft, at this time, was put at 2,000 yards (or 2½ minutes) from the Ops. Block. Cottesmore's ORP had yet to be completed; when ready, the taxi distance from the QRA site would be "a few hundred yards". However, crews at this base, at this time, could not obtain access from the QRA site to the runway at the ORP end due to obstruction of the perimeter track. Here, the memorandum observed: "The aircraft normally taxi nearly two miles to the other end of the runway." The Go-Bag was kept in a cabinet in the Ops. Room, but accompanied the crew to the QRA aircraft. The alerting system (during the night) was warning bells and/or klaxon at the Officers' Mess, squadron offices, sleeping quarters, groundcrew offices and recreation rooms. Aircrew normally reported to the Ops. Room, where they took the Go-Bag from the cabinet.[68]

Roy Brocklebank sums up QRA crew comfort, with no purpose-built Alert facilities on main bases or dispersals: "Where there was nothing, caravans were provided. These could well have been of World War 2 vintage. No money was wasted on frippery. Some dispersals fared better than others. Ballykelly had better dispersal accommodation than for the resident Shackleton squadrons – we had flush toilets. At Brawdy, I think accommodation was at the opposite end of the airfield. At Pershore we had caravans. I believe Scampton had caravans sited at Ops. Coningsby and Cottesmore used the Messes. In contrast, the Alert facility at Goose Bay for the SAC KC.135 tankers was semi-underground, had several exit tunnels and all mod cons – dormitory, messing, recreation, briefing, etc. Had proper facilities been provided at each ORP or QRA dispersal, suitably sound-proofed, of course, and crews sleeping in flying kit, RS10 could have been maintained, rather than RS15".[69] Indeed, in an acute crisis, it should have been possible to hold *all* dispersed aircraft not on 24/7 RS05, by rotation, at RS07, by the simple expedient of positioning suitably-equipped caravans next to parked aircraft.

Andrew Brookes (1982) suggested the contrast between the V-Force and SAC was a matter of style: "The differences were largely a matter of national character – at a V-Force base there were no loud slogans on the gate, proclaiming 'Peace is our profession', no pistol-packing guards everywhere, few dramatic red telephones …"[70] But it was much more than that. SAC's resources and scale were of a different order

[68] AIR 14/4327, Bomber Command, Operational Research Branch, Memorandum No. 258, "The Quick Reaction Alert in Bomber Command", October 1962, Appendix C.
[69] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 9/4/20.
[70] Brookes, *V-Force: The history of Britain's airborne deterrent*, 82.

of magnitude. SAC aimed to have one-third of its aircraft on Ground Alert at all times. SAC Ground Alert began on October 1 1957 and there were 10 forward bases: four in the UK, three in Spain and three in Morocco, with six B.47s held at Alert on each.[71] Later, generous funding provided for continuous B.52 upgrades. In 1972 Philip Goodall wrote a report on his exchange tour with SAC. He described new generation equipment and the *sixth* upgrade of B.52 ECM outfit, under the "Rivet Ace" programme.[72]

The Cuban Crisis

The 1962 QRA report, in effect, described the minimum responses to war in place on V-bomber main bases at the time of the Cuban Crisis. How ready was Bomber Command? The report set out the results of QRA force exercise alert response times over three duty periods: normal (08.30-17.30), normal off-duty (17.30-23.00 and 07.30-08.30) and sleep period (23.00-07.30). Average time from Alert to RS05 (Cockpit Readiness) was 4.2 minutes – normal and normal off-duty (6.6 during the sleep period; 5.1 minutes, all periods). The average time from Alert to engines started was five minutes (normal duty), 5.8 minutes (normal off-duty) and 7.9 minutes over the sleep period (5.7, all periods). Times from Alert to RS02 (wheels rolling) were: 7.7, 8.8 and 8.2 (8.1, all periods). It was noted that "average reaction times are all within the Alert requirements."[73] That might be so, but, without dispersal and an element of continuous RS05, the fact remains that in a simultaneous launch/low trajectory IRBM attack by the Soviets (assuming required missile numbers were available), the V-bombers would have been destroyed on the ground.

In October 1962 – on paper at least – Britain posed a significant nuclear threat to the Soviet Union, as described by Jim Wilson (2012): "One has only to look at the numbers of weapons lined up on each side of the Iron Curtain in 1962 to appreciate just how significant the British strike force was."[74] The more important question, of course, was: How significant would it be *after* a Soviet pre-emptive attack? That said, the Cuban Crisis came "just when the Command was reaching the peak of its operational efficiency …", according to the then Senior Air Staff Officer at Bomber Command, Air Vice-Marshal Stewart Menaul.[75]

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[71] Young, *The American bomb in Britain,* 94.
[72] Goodall, *My target was Leningrad*, 160.
[73] AIR 14/4327, Bomber Command, Operational Research Branch, Memorandum No.258, "The Quick Reaction Alert in Bomber Command", October 1962.
[74] Jim Wilson, *Britain on the brink: the Cold War's most dangerous weekend, October 27-28 1962* (Barnsley (UK): Pen & Sword, 2012), 121.
[75] Menaul, *Countdown*, 114.

Sir Kenneth Cross, AOC-in-C Bomber Command, brought V-bombers and Thors to Alert Condition 3 (Precautionary Alert) on Saturday October 27 1962 and this remained in force until November 5. The HQ No.1 Group Operations Record Book records the order for Alert Condition 3 from BCOC at 13.00 that Saturday.[76] At main bases, aircraft planned to operate from those bases were to be prepared for operational take-off, whilst the rest were to be armed and prepared for dispersal.[77] The AOC-in-C went further, as recounted by Twigge and Scott (2014):

> …orders were given to double the number of bombers on QRA. At most stations within Bomber Command this would have required six aircraft in total, although at RAF Waddington the number of QRA bombers was trebled… resulting in nine fully-armed Vulcans at 15 minutes Readiness. To arm the extra aircraft on QRA, additional Yellow Sun thermonuclear weapons were transported to all operational V-Force bases from the Faldingworth nuclear storage site in North Lincolnshire.[78]

Air Vice-Marshal Menaul (1980) wrote of V-Force ability to deliver a crushing blow, but disregarded exposure to destruction on the ground: "The bombers were nearer to Russia by about five hours than aircraft of SAC based in America and Thor's reaction time from the order to launch until impact on targets in Russia was about 25 minutes. This represented a very impressive megatonnage (230 megatons on 230 targets, to be precise), most of which would have reached their assigned targets if orders had been given to attack. What is more important, the Russians knew it too."[79] Some might take issue with Menaul's 230MT figure and, certainly, his claim that most weapons would have reached their targets, given that BMEWS had yet to enter service and considering the potentially disastrous consequences of a Soviet pre-emptive strike in the absence of dispersal.

Commenting on Cuba nearly 20 years afterwards, he continued in much the same vein: "… the British contribution in terms of Thor and the V-bomber force, so close to the Russian homeland, was obviously not entirely ignored by Russia in reaching her decision to withdraw the missiles from Cuba. It will be remembered that the combined Allied bomber forces rained down more than two million tonnes of bombs on Germany in the six years of war 1939-45 … In 1962, Bomber Command alone could have

[76] AIR 25/1703, Operations Record Book, No.1 Group, October 27 1962.
[77] Peter Hennessy, *The Prime Minister: The office and its holders since 1945* (London: Penguin, 2001), 121.
[78] Twigge and Scott, *Planning Armageddon*, 123.
[79] Menaul, *Countdown*, 115.

despatched the equivalent of 230 million tonnes in one raid, enough to destroy every major city or centre of population in the entire Soviet Union. A sobering thought."[80] Also sobering was the likely reality of, perhaps, only a small proportion of V-bombers crossing the North Sea with only a very small fraction of 230MT, *before* attempting to penetrate Soviet defences. Most importantly, it seems reasonable to assume that the major Soviet concern over the British threat, at this time, would have been the destruction of all Thor sites before launch. This, taken alone, completely undermines the view that the Soviets would favour "simultaneous burst" – which would have given the Thors enough time to launch.

Menaul regarded Skybolt as combining the best elements of manned aircraft and missiles. He was dismissive towards the submarine-based deterrent and continued to ignore the bombers' exposure to destruction on the ground in the missile age. Writing over a decade after the British strategic frontline passed to Polaris, he added: "To produce a force of submarine-launched missiles with equivalent capacity to that of Bomber Command (230MT) would have required at least 20 submarines at a cost considered beyond Britain's ability to pay in the economic climate then prevailing."[81] Menaul, however, should have compared the *virtually guaranteed* delivery of the attack weight of one Polaris submarine on patrol against the likely smaller delivered tonnage of the few V-Force survivors able to release their weapons (perhaps amounting to around 3 MT). One Polaris submarine – rather than 20 – would have delivered a heavier blow than a handful of surviving bombers.

On the squadrons, crews noticed the departure from routine as the Cuban Crisis deepened. On 50 Squadron at Waddington, AEO Martin Anscombe saw Wing QRA aircraft double in number: "We had six Vulcans fuelled, bombed up and ready on QRA … We ended up with four of the six QRA aircraft on the scramble bays at the end of the runway. We may have gone as far as start engines during that QRA, but we didn't taxi because recovery time taxiing back and refuelling would put the aircraft out of Readiness for too long."[82] Nav/Radar Squadron Leader Hickmore remembered RS15 aircraft at Waddington increasing to nine: "Initially, Bomber Command reacted slowly as the USAF increased the alert state."[83]

[80] Ibid, 116-117.
[81] Ibid, 117.
[82] Martin Anscombe, Vulcan AEO; interviewed: 28/2/18.
[83] White, *The King's thunderbolts*, 183.

For Air Vice-Marshal Michael Robinson, a former CO of 100 Squadron, Cuba was a highlight:

> For me, as a V-Force Squadron Commander, a peak of the RAF's nuclear story was reached on the afternoon of Saturday, October 27 1962, when all available Victor aircraft and crews at RAF Wittering were brought to Cockpit Readiness 05. Each aircraft was loaded with one freefall thermonuclear weapon, the crews had their Go-Bags, with all of the necessary route and target information and authorisation codes.[84]

As expected, there were difficulties preparing the three squadrons of US-armed, SACEUR-assigned Valiants at Marham, as described by Twigge and Scott (2014):

> …it soon became evident that the USAF Custodial Officers could not maintain physical control of all the nuclear weapons, as they were only established with sufficient manpower to monitor the QRA compound and the nuclear weapons storage area. Therefore, at the discretion of the Commanding Officer USAF, control of the weapons was handed over to the Base Commander. The result was 24 Valiant bombers (each armed with two US nuclear weapons) under the effective operational control of Bomber Command.[85]

There were also human considerations. Dick Fuller was a 49 Squadron Valiant Co-Pilot at Marham. He and his wife went shopping in King's Lynn; on returning they found all aircrew were confined to base:

> I remember thinking it odd when, at a certain point, all the animals in the RAF Regiment dog compound began to howl. I decided to take a bath. Then the sirens sounded, signalling the order to go to five minutes' Readiness. Usually, the five-minute alert was stood-down after a short while, but not on that day. This felt very different. My bathwater went cold. Looking back, it seems odd that we were not dispersed. That night Marham's Mess was packed with people having more than one drink. Later, I talked to crews who had been on QRA when it looked like we were going to war. They had been shocked rigid.[86]

Vulcan AEO Peter West was at RAF Coningsby with 12 Squadron when Cuba flared:

> Even when loaded with a live weapon and ready to take-off, nobody believed we would actually have to do it. However, I did have a few nightmares afterwards. I was in the aircraft, taking off. There were weapons going off around me. I suppose it was something that just had to be sweated out of me. At that point, we had a family of three very young children, aged five, three and one.[87]

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[84] Air Vice-Marshal Michael Robinson, "Summary of the previous RAF Historical Society seminar on the origin and development of the British nuclear deterrent 1945-60", RAF Historical Society, *Journal 26* (2001): 10-15.
[85] Twigge and Scott, *Planning Armageddon*, 127.
[86] Dick Fuller, Valiant Co-Pilot; documents/text provided: 29/10/20.
[87] Peter West, Valiant/Vulcan AEO; interviewed: 30/4/19.

Many constituted crews grew close, rather as a family; they drew together in the wake of Cuba, as recalled by Peter West:

> I don't remember meaningful discussions about the deterrent or the "morality" of nuclear weapons. Yet, at the same time, I remember our discussion in the Crew Room after Cuba. We sat down and, over coffee, chatted about how we had reacted to the crisis. We had watched it build on TV. It hadn't been a huge surprise when the doorbell went on that Friday. The RAF Policeman standing there told me to get my kit and go to Operations as soon as possible. I said to Mary: "If you hear us take off, it means we are going". We had never talked about it before. I told her – if she heard us go – to get the kids in the car and drive. Don't pack anything beyond essentials. I told her to make for Skye. When I returned home I felt like a bloody fool. How far could she have got before being obliterated?[88]

RAF Cottesmore went to high alert during the crisis, with crews in flying kit at the QRA site. Bomb-bays were loaded with megaton weapons. Dave Beane was an AEO on 10 Squadron: "It felt like – and was – a hair-trigger situation. The prevailing view was that we had been trained to go and, if we had to, we would do it and do it well".[89]

Norman Bonnor was also at Cottesmore during the crisis. A Victor Nav/Radar with XV Squadron, he watched the QRA build-up:

> On Saturday, October 20 1962 the Cottesmore aircrew and groundcrew were told not to leave the base or the local area … by the time Cuba flared up, we were carrying Yellow Sun 1 (and) in the process of converting to Yellow Sun 2. There were not enough of the new Yellow Sun weapons available at Cottesmore and the decision was taken to load some aircraft with Red Beard, a tactical weapon with a much lower yield. One or two of the seven aircraft XV Squadron generated during the Cuban Crisis week had a Red Beard rather than Yellow Sun loaded. We all ended up at Cockpit Readiness on the final Saturday, October 27. We now had nearly 20 aircraft bombed up and ready to go at Cottesmore. I'm sure we would never have been able to get them all off in time … We held on to the thought that the Soviets would never attack. The West's retaliation would be enough to send them back to the Stone Age. Everything was readied – even the Coastal Command Shackletons were bombed up to attack Soviet shipping around the North Cape. When the crisis receded, the relief was immense. There was a bit of a party at Cottesmore! [90]

Who gives the order?

A CAS meeting on January 15 1964 considered Bomber Command responses to BMEWS alarm levels. There was much discussion over delegation of powers to

[88] Ibid.
[89] Dave Beane, Victor AEO, 10 Squadron, RAF Cottesmore; Vulcan AEO, 27 Squadron, 101 Squadron; amongst documents/text provided: 27/10/20.
[90] Norman Bonnor, Victor Nav/Radar; amongst documents/text provided: 1/11/20.

authorise a war scramble.[91] This meeting was referred to in a letter from VCAS to ACAS Ops. a month later (February 17 1964): "An officer of Air Vice-Marshal rank is now available at all times to speak to the Bomber Command Operations Centre …"[92] The January 1964 meeting arose from a minute from the VCAS of December 24 1963, calling for more flexible scramble arrangements. The background was the Intelligence estimate of a very low likelihood of a bolt from the blue attack and ministerial reluctance to entertain "very hair-trigger" arrangements, despite the fact that scrambled aircraft would be under Positive Control.[93] The December 24 minute from the VCAS to the CAS noted: "The BMEWS site at Fylingdales will become fully operational during the first quarter of 1964 and I have been considering whether any special measures are needed to ensure that our present arrangements for releasing the deterrent against a bolt from the blue attack are compatible with the reduced warning time which will be provided by Fylingdales." The note then continued:

> In brief, the problem is that Bomber Command constantly maintain a proportion of the MBF, at present 13 aircraft, at 15 minutes' Readiness. This QRA force can be airborne in about six to seven minutes from the order to scramble. The minimum warning time (ie. the time between generation of an Alarm Level and the time of the first impact) from Fylingdales of a Soviet attack is estimated to be between seven and 9½ minutes depending on the range and trajectory of the missiles. Thus, if the QRA force is to react to a bolt from the blue attack, it is necessary that they be given the order to scramble with the minimum of delay. This timing precludes any reference to outside authorities.[94]
>
> Prior to the installation of BMEWS … the decision to scramble the QRA force against a bolt from the blue attack was related to the reaction of SAC which, in turn, was based on information provided by the BMEWS sites in the USA. At this time, Bomber Command's procedures were as follows:
>
> a. On receipt of an Alarm Level 3, the Duty Controller (Wing Commander/Squadron Leader) at BCOC brought the QRA force to Cockpit Readiness. He also informed the C-in-C or SASO (Senior Air Staff Officer), if available, and the Duty Group Captain (Operations), who is available throughout the tour of duty at 15 minutes' standby.
> b. Assuming that the C-in-C or SASO could not be contacted or that they were not able to reach the BCOC by the time the Alarm Level changed to either 2 or 1, the Duty Group Captain scrambled the force under Positive Control.[95]

[91] AIR 8/2369, Note of CAS meeting, Air Ministry, January 15 1964.
[92] AIR 8/2369, letter from PS to VCAS to ACAS (Ops.), February 17 1964.
[93] AIR 8/2369, Note to CAS from PS, December 31 1963.
[94] AIR 8/2369, letter from VCAS to CAS (VCAS 7977), December 24 1963.
[95] Ibid.

This meant the QRA force could be launched, in certain circumstances, by a Group Captain, without reference to a higher authority. The American system was very different:

> The decision to scramble the SAC equivalent of our QRA force is never delegated below two-star level, whereas our procedures permit this to be done, in certain circumstances, by a Group Captain. Such action would be justified if it could be guaranteed that BMEWS will never transmit false alarms and, therefore, the force would only be scrambled against a real attack. It is not possible to give any such guarantee. In addition, it is questionable whether the Prime Minister intended that the dispensation … should be delegated below senior air rank.[96]

Clearly, one worry was the risk of flying with live weapons, a complete departure from past practice, together with the political and public storm which would surround a false alarm scramble of armed aircraft. Here, the December 1963 VCAS minute commented:

> I think we must anticipate that Fylingdales may generate false alarms and that the QRA force will be scrambled in response. The question is, therefore, whether a Group Captain should be permitted to authorise such reaction. Although the force would be under Positive Control and would return to base unless the AOC-in-C was given political authority to release nuclear warfare, there is always the possibility of an accident. Thus the decision to scramble is of considerable consequence, especially as Press and Parliament would inevitably learn that the QRA force had been launched on a false alarm. I am sure that we would be open to criticism if it then became known that the authority to scramble was given by a relatively junior officer. I consider, therefore, that until Fylingdales has been proved beyond reasonable doubt, that the AOC-in-C Bomber Command should not delegate his authority to scramble the QRA Force to officers of less than air rank.[97]

A year passed and this proposal, requiring delegation to no lower rank than Air Vice-Marshal, proved challenging. On May 20 1965 CAS reviewed delegation with the VCAS and the AOC-in-C Bomber Command. A post-meeting note stated: “The AOC-in-C explained that the arrangement had not proved easy to operate in practice; more important, however, experience showed that the action which had to be taken in the bolt from the blue situation in question was such that no real exercise of judgement was required – successive steps were virtually automatic and admitted of no alternative choice once it had been checked that the information from Fylingdales was

[96] Ibid.
[97] Ibid.

genuine and not purely for exercise purposes." In these circumstances, he supported a return to the "Duty Group Captain" scheme. CAS accepted this view.[98]

To conclude, the missile threat to the MBF could have been countered, to some degree, by Airborne Alert and/or dispersal to remote bases overseas, in a time of emergency, had Bomber Command been equipped and resourced accordingly. These options, however, were not available and the reasons why will be explored in more detail later in this narrative. The challenge, therefore, was to optimise UK Ground Alert, the sole option available to the MBF. The key was to make the best possible use of very short warning and reaction times, given the threat from low trajectory IRBMs. The new Fylingdales BMEWS would offer only around four minutes warning in a simultaneous launch attack, yet V-Force QRA and main force dispersal and regeneration exercises were based on Readiness State 15 minutes. The latter assumed a Soviet staggered launch for simultaneous burst in Europe and the US (giving the UK the longer "American Warning"). The evidence examined, however, provides no explanation of why the Soviets should forego the advantages of simultaneous launch attack, with low trajectory IRBMs offering the short warning of around four minutes. This suggests that only V-bombers at RS05 (Cockpit Readiness) and poised for RS02 (engine start) had a chance of survival, but RS05 could not be maintained for more than a few hours without crew rotation. It follows that the only viable Ground Alert posture under threat of war would require holding part of the main force dispersed and at RS05 by double manning. The Cuban Crisis, however, exposed a fundamental weakness of Ground Alert. Would the political will exist to order dispersal? In October 1962, the V-bombers stayed on their main bases to avoid "provocation" – where they would almost certainly have been destroyed had war come.

[98] AIR 8/2369, note, May 20 1965, from M.E. Quinlan, PS to CAS, to PS to VCAS.

– 5 –

VULNERABILITIES ON THE GROUND: REDUCING EXPOSURE

This chapter reviews measures taken to reduce MBF exposure on the ground. The assessment begins with an obvious counter – Airborne Alert, possibly as a short-term response to a grave crisis. The reasons for its lack of viability in the V-Force context are identified. A second option, dispersal to remote bases overseas, is also considered. Its limitations are identified (primarily the lack of target cover). Ground Alert was the only viable option for the MBF. Measures taken to enhance Ground Alert are considered: Alert Condition 1 – the "maximum effort" response to a threat of imminent attack, initiatives to reinforce Alert and Readiness and the development of a network of dispersal airfields.

Seeking a solution: Airborne Alert

Many measures were taken to reduce V-Force exposure on the ground, but nothing could change geography and missile flight time. Planners fully appreciated the observation of Bernard Brodie (1959): deterrence "dictates primary concern with the survival of a retaliatory force of sufficient size following enemy attack."[1] What was required was survival of enough capacity to inflict damage at a level judged unacceptable to the enemy. UK-based Ground Alert's obvious limitations prompted a search for alternatives. One model already existed: SAC's Airborne Alert – the maintenance of a proportion of the bomber force in the air, ready to fly war sorties if so ordered.

Airborne Alert, examined repeatedly by British planners, lacked viability for the V-Force, yet the idea resurfaced regularly, given its superficial attractions. The impossibility of operating V-Force Airborne Alert was exposed as early as mid-1959, yet it was hard to accept that Ground Alert was the only option open to V-bombers. Many refused to accept reality and, consequently, Airborne Alert appeared on the agenda for a Defence Board meeting in April 1960. It was even resurrected in the

[1] Bernard Brodie, "Strategy in the missile age" (RAND, 1959): 283; cited by Richards, "Time is no longer our ally", 39.

early 1970s, as one element of a rather far-fetched proposal for an air-delivered successor to Polaris. Twelve years earlier, in 1959, a Bomber Command memorandum examining Airborne Alert during an emergency opened bluntly: “As the threat to bomber bases from ballistic missiles increases, straightforward dispersal of the force becomes less effective as a means of ensuring its survival and alternative means must be considered. One such method is to keep a proportion of the force airborne.” This would be very costly and would mean accepting risks associated with constant carriage of live nuclear weapons. Significantly, it noted that the normal rate of MBF flying was the equivalent of only one aircraft for every three squadrons continuously in the air (about 4% of strength).[2]

This report confined itself to “practical possibilities”: an airborne readiness system operating for short periods only, in an emergency. It assumed that:

- The force available to provide Airborne Alert would comprise 10 squadrons of bombers and two of tankers, on main bases.
- At any time, 75% of aircraft (bombers and tankers) were available for first-line flying (ie. 60 bombers and 12 tankers). It also assumed that 90% of crews were available for operational flying.[3]

This memorandum identified the difficulties: “If bombers were operated in this way, it would be possible to preserve a proportion of the force in the event of an attack on bases, but very few of the aircraft airborne at any time would be operationally effective. The majority would have to land and refuel before setting off on an operational sortie and the problems of recovery and refuelling in the operational environment assumed would be enormous.”[4]

There were other concerns: “… in practice, aircrew fatigue is in any case likely to preclude operation for any length of time … It seems, therefore, that between 10 and 15 bombers continuously airborne is the best that can be expected under the conditions of operation assumed. For short periods of time the number could be increased to about 20 by overworking aircrew and accepting abnormal landing risks.”[5]

[2] AIR 14/4286, Bomber Command, Operational Research Branch, Memorandum No. 197, “Keeping a proportion of the bomber force airborne in an emergency”, July 1959.
[3] Ibid.
[4] Ibid.
[5] Ibid.

For aircraft airborne and held in a specified area until the "Go" order, the amount of waiting time available to give that order was very small – less than half an hour – if the bombers were to retain sufficient fuel to complete their sorties. A theoretical exercise exposed the problems of fuel consumption and range. If the entire available force – 60 bombers and 12 tankers – scrambled simultaneously and was held at a point some 200 miles from base, on the way to targets, after one hour's delay about 40 bombers could be given sufficient fuel to continue their sorties, or about 20 after two hours.[6]

SAC had the big numbers – aircraft and crews – to make Airborne Alert work, but this went far beyond V-Force resources: "… the concept of airborne readiness is of limited application in Bomber Command … There is, however, a case for demonstrating a capability in this direction, since a bomber airborne in an unknown position over friendly territory is less vulnerable to missile attack than any offensive weapon yet in service and as such constitutes a powerful deterrent."[7]

Airborne Alert was of such potential significance that it was the subject of an April 19 1961 Commons Question. Julian Critchley MP asked the Secretary for Air what it would cost to maintain 10% of the V-Force on standing Airborne Alert. Julian Amery offered a creative reply: "Because of its capacity for quick reaction to warning of attack, the V-bomber force provides an effective deterrent without recourse to Air Alert. To maintain a standing Air Alert with 10% of the force would involve not only an increase in flying maintenance costs but also substantial changes in the present organisation of Bomber Command. I am not in a position to say precisely what the cost would be."[8] That said, the planners quietly went on considering methods which might produce a form of Airborne Alert in the Skybolt era.

In March 1962 – with Skybolt still in prospect – Bomber Command produced a report on aircraft utilisation during continuous Airborne Alert. This involved both freefall bombers and those carrying Blue Steel. Chief Research Officer Tom Kerr said that research had examined the number of sorties per 24 hours, and hours per month, on Vulcan 2 aircraft required to keep one aircraft airborne when carrying freefall, Blue Steel and Skybolt weapons. The patrol area was a corridor off the Norwegian and

[6] Ibid.
[7] Ibid.
[8] Richards, "Time is no longer our ally", 36-60; citing Hansard HC Deb., April 19 1961, vol.638.

Danish coasts. He then summarised Bomber Command's extremely limited Airborne Alert capability:

> The number of aircraft which can be kept airborne depends upon the conditions assumed and the aircraft utilisation. Assuming an aircraft carrying Blue Steel, with overload fuel and landing at an alternative base, combined with the present utilisation, one aircraft requires 3.8 squadrons to support it. If the utilisation is doubled, then the number of aircraft on patrol can be doubled. Refuelling in the air does decrease the Vulcan utilisation required, but to save 100 Vulcan hours, 200 Valiant tanker hours are required.[9]

Clearly, Airborne Alert was no solution to the threat of V-Force destruction on the ground. Nevertheless, the view that Airborne Alert should be practiced in future exercises, including use of tankers to provide insurance against unforeseen delays in the "Go" order, was supported subsequently by the Defence Board. It saw value in projecting some level of Airborne Alert capability to the Soviets. One such exercise, the first of its kind, was Trial No. 441, involving Waddington's Vulcan 1/1A aircraft during March 1962. An ORB memorandum on this trial noted that it was designed to keep one aircraft out of six airborne continuously for 14 days. This study concentrated on aircraft servicing and the main objective was achieved: it was feasible to maintain this capability for a limited period, although that had little relevance to retaliatory strike.[10] Within its narrowly-defined scope, Trial 441 succeeded, proving that one in six aircraft could be kept airborne for 14 days – but to what purpose? The aircraft flew normal training sorties with no flight refuelling and, therefore, had no viability as part of a retaliatory force.

The threat of destruction on the ground remained. Unpalatable truths were confronted in Bomber Command's March 1962 report on exposure to missile attack. The chance of escaping low trajectory missiles was small and the only valid posture, according to the report, was some form of Airborne Alert. In this way, a circular, persistent line of argument developed around an "obvious solution" which remained out of reach in the British context.[11]

What drove this constant re-examination of Airborne Alert, given negative results from several studies? Part of the answer involves Julian Amery, Secretary for Air. In April

[9] AIR 14/4211, Bomber Command, Operational Research Branch, Memorandum No. 28, "Aircraft utilisation during a continuous airborne alert using freefall and stand-off weapons", March 1962.
[10] AIR 14/4315, Bomber Command, Operational Research Branch, Memorandum No. 245, "Trial No. 441: An airborne alert, analysis of the aircraft servicing aspects", April 1962.
[11] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No.241, "The vulnerability of the MBF to ballistic missile attack," March 1962.

1961 he may have answered a Commons Question by dismissing the need for Airborne Alert, but his true view was the polar opposite. During a meeting with CAS and others on February 19 1962 – to discuss a successor to Skybolt by 1975 – Amery pressed hard for Airborne Alert, choosing to ignore its futility in the British context. In a note summarising this discussion, Amery confronted the possibility of an attack on the UK with multi-megaton weapons:

> It would seem reasonable to assume that the Soviets could deliver such an attack from manned aircraft or ballistic missiles, if not at once at any rate in the next year or so. This means that the Soviets will be able, for a much smaller effort than hitherto, to launch an attack which would make our ground alert posture ineffective.[12]

Amery continued in a way that suggests he had no real understanding of Airborne Alert:

> If these assumptions are true, then we must be prepared to go over to an Airborne Alert posture from, say, next year onwards in the event of an emergency. We can, I think, afford to discount the possibility of a Soviet bolt from the blue on the United Kingdom, at any rate in the foreseeable future. But readiness to go to Airborne Alert in emergency means, presumably, a level of training amounting to random Air Alert from now on.[13]

Senior Ministers were willing to express an honest view of the weaknesses of Ground Alert, but only when arguing for favoured remedies. In any event, their views were rapidly overtaken by events: Skybolt's cancellation, adoption of the submarine-based deterrent and fresh studies further revealing insurmountable problems surrounding Airborne Alert. The capability gap created between Skybolt's cancellation and the arrival of Polaris would be bridged by a switch to low level strike and initiatives to help at least some bombers escape destruction on the ground: enhanced QRA, dispersal and faster response through initiatives such as SIMSTART. Of course, it should have been obvious that Airborne Alert was a non-starter. V-bombers, in contrast to B.52s, had no room for extra crew and relatively poor endurance without extensive tanker support. This is why commercial aircraft (designed and built for high utilisation) were considered as potential Skybolt carriers. One proposal was for 36 VC-10s, each carrying four Skybolts.[14] In the long run, all plans for Airborne Alert, capable of delivering a minimum retaliatory attack in response to a pre-emptive strike, came to

[12] AIR 19/940, note by the Secretary of State for Air, February 19 1962.
[13] Ibid.
[14] Peter Hudson, "A view from Whitehall", Deterrence Special Edition, *Air Power Review*, Vol. 20, No. 2 (Summer 2017): 93-94.

nothing. The V-Force, on Ground Alert, would "muddle through" until Polaris arrived. As for the Americans, SAC brought Airborne Alert to an end in 1968 following "embarrassing accidents" involving nuclear weapons.[15]

No solution in overseas dispersal

There was another potential alternative to UK Ground Alert: dispersal to remote bases overseas. In October 1959 (at a time when a long-range ASM was still expected to arm the V-Force), Bomber Command produced a study of target coverage from overseas bases:

> The main objective of overseas dispersal is to diversify the target system which the Russians must consider by removing a proportion of the deterrent force out of the UK and, at the same time, ensuring that the overseas bases are outside the range of IRBMs. In this way, the attraction of a surprise attack on the UK is much reduced. Overseas bases in Bermuda, Canada, Africa, the Far East and even Australia might be considered, using a combination of staging, flight refuelling and final launching of a long-range guided missile to reach Russian targets.[16]

This looked at the weapon system in immediate prospect: a Blue Steel-armed Vulcan B. Mk. 2. Assuming some fuel in bomb-bay tanks and normal fuel reserves on landing, range was calculated at 3,300NM (slightly more for freefall aircraft carrying more fuel). Range could be increased by using fuel reserves normally allowed for landing, "in which case the crew will bale out over the terminal base." It went on to add: "Flight refuelling, using Valiant tankers stationed with the bombers, is another effective method of increasing target coverage, so that there are four main possibilities – a normal landing or a bale-out over terminal base, both with or without flight refuelling. If a second strike is not required, the bomber can land or the crew can bale out over any convenient base in friendly territory … The closer this base is to Russian territory, the greater will be the target coverage available…"[17]

The study examined target coverage available from various overseas bases – using a list of 120 targets – and concluded:

> … a significant number of targets can be reached from the vicinity of Nairobi by a Vulcan Mk. 2 carrying Blue Steel if the crew bale out over Cyprus. Small increases in cover are possible if alternative terminal bases closer to Russia are

[15] Lindsay Peacock, "Strategic Air Command", in *V-Force: ready for the unthinkable* (London: Newsdesk Communications, 2008), 13-14.
[16] AIR 14/4210, Bomber Command, Operational Research Branch, Memorandum No.S.26, "Target cover from remote dispersal bases overseas", October 1959.
[17] Ibid.

> used … but flight refuelling is required to provide target cover from all the bases considered. If Valiant tankers are stationed with the bombers, ample target coverage is available from Nairobi, the Maldives, Salisbury and Canada. Even from bases as remote as Singapore or Bermuda, some targets can be covered.[18]

For Vulcan Mk. 2s with Blue Steel 1 (150NM maximum range at high altitude), they could reach 13 Russian targets from Nairobi and land back in Cyprus, or 45 targets if baling out over Cyprus. This increased to 89 and 109 respectively, if refuelled. From the Maldives, Blue Steel Vulcans could reach nine targets unrefuelled, but only by baling out over Cyprus on recovery. The position improved dramatically with refuelling, reaching 50 targets with a landing in Cyprus or 99 if bale-out was accepted. Salisbury-dispersed Blue Steel Vulcans could reach 34 targets and make a recovery landing, or 54 if bale-out was accepted – but only with refuelling in both cases. Refuelling would also be required for the bombers if operating from Singapore, allowing only one target to be reached with a recovery landing, but 38 within reach with bale-out over Cyprus. Refuelled Vulcans from Ottawa could attack 13 targets and return to land in the UK (49, if bale-out was accepted). Aircraft dispersed to Prince Edward Island could reach four targets without refuelling (bale-out required); with refuelling they could reach 28 and land back in the UK, or 79 with the bale-out option. Bermuda was the worst option. Even with refuelling, the Vulcans could reach only four targets and land back in the UK (16 if the crew baled out).[19]

Blue Steel Mk. 2 (600NM plus) would have transformed matters, with much enhanced target coverage – especially in the refuelled/bale-out modes. Nairobi was the most advantageous location, given a 600NM stand-off weapon and with no refuelling – 60 targets within reach with a Cyprus recovery (99, bale-out). Not surprisingly, the 1959 study stressed the importance of even longer-range weapons: “A range of about 800NM allows most targets in Western Russia to be attacked from outside the defences but 1,200NM would be required to provide complete tactical freedom in choice of the launch point.” On the vulnerability of overseas bases, the Memorandum commented:

> The use of overseas bases would increase the deterrent value of the bomber force only if the bombers based there were more difficult to destroy on the ground than those based in the UK. It would be possible to attack the overseas bases considered by means of long-range bombers, or inter-continental ballistic missiles based in Russia, but the operation would be a difficult one (ranges are

[18] Ibid.
[19] Ibid.

> in excess of 3,000NM) and coordination of such attacks with other vital offensive operations would be a serious problem.[20]

This Memorandum warned against penny packet deployments: "… a sufficient number of bombers must be stationed overseas to provide a serious threat to Russia. If only a token force were deployed, the threat might be assessed as within tolerable limits and the deterrent value … would then be negligible." It also pointed out that deterioration in accuracy (at that time) over a longer range would mean that 90% assurance of destruction of a remote base would require many more missiles … (from four against a UK base to up to 16 for an overseas base).[21]

This significant study of overseas dispersal concluded that unrefuelled Blue Steel V-bombers would pose a significant threat only from Nairobi … "and then only if drastic methods of stretching the effective range of the bombers are employed." If Valiant tankers were also deployed, a significant threat could be projected from Nairobi, the Maldives, Salisbury or Canada, "while some targets can be reached from bases in Bermuda or Singapore." Given a 600NM range Blue Steel 2, "flight-refuelled bombers from all the bases considered could provide sufficient target cover to constitute a severe deterrent threat to Russia. A weapon having a range of 1,200NM would increase tactical freedom and permit all launchings to be made from outside the Russian defence zone." So, in essence, the absence of a long range ASM ruled out dispersal overseas as a viable option (with the limited exception of Cyprus, where two squadrons of aircraft were deployed, post Polaris handover, to cover southern Russian targets). [22] This memorandum recommended further study of dispersal overseas. Yet, an expanding Soviet missile force and enhanced long range accuracy eroded any potential advantage of the overseas option – aircraft were just as likely to be destroyed on foreign dispersals as they were on UK dispersals.

Confronting realities: UK Ground Alert

Ballistic missiles changed everything, as outlined by Twigge and Scott (2014):

> In 1949, Britain planned on a warning period of 3-4 months before going to war. By 1960, this had been reduced to 15 minutes. To meet these new conditions, British deterrent policy was re-examined. The outcome was twofold: first, active air defence was effectively abandoned and increased emphasis placed on early warning and strategic Intelligence. Second, in the event of a unilateral British nuclear response, Bomber Command was directed to attack Soviet cities. To

[20] Ibid.
[21] Ibid.
[22] Ibid.

> implement this strategy and maintain the credibility of the deterrent, further measures were introduced. These included a rapid reaction capability, centralisation of operational control, an unambiguous chain of command, improved communications and the introduction of Positive Control.[23]

Was this enough? In the absence of Airborne Alert, the priority was to avoid almost complete annihilation on the ground. The 1960s RAF did its best. With extremely limited means, it sought to preserve the capability and credibility of the V-Force, despite the growing missile threat and the extraordinarily heavy spend on Soviet air defence. Vulcan Captain Roger Dunsford underlines the fact that both sides could not rule out the possibility, albeit remote, that they could fall victim to a first strike:

> …demonstrating that the V-Force was capable of penetrating Soviet defences *in the absence of a prior missile strike by the USSR* remained a critical tool of deterrence throughout the 70s and (arguably) the early 80s. My experience of Red Flag – successfully penetrating realistic Soviet defences at very low level, at night – in 1979 speaks to exactly that. This aspect of deterrence – forcing the other side into BOTH a defensive and offensive arms race – proved crucial… Many have argued, and I find it very hard to disagree, that it was this massive military expenditure that contributed greatly to their economic woes and, ultimately, to the collapse of the Soviet Union.[24]

Time pressures ruled V-Force ability to generate weapon systems, scramble and fly a war sortie. Bomber Command Alert and Readiness (BCAR) procedures evolved in response to the growing missile threat. In the Summer of 1961, some months before the introduction of QRA across the MBF, BCAR was amended. This increased the number of Alert Conditions from four to five. There was a new Alert Condition 1, under which 25% of the force could be held at continuous Cockpit Readiness (RS05). This recognised the threat of overwhelming destruction on the ground unless a proportion of aircraft could be maintained at Cockpit Readiness RS05 (rather than RS40, which then still applied, before the move to RS15) for extended periods during a grave crisis. The five Alert Conditions became:

5. Normal peacetime conditions
4. Precautionary alert
3. Aircraft generation
2. Aircraft dispersal
1. “Partial” Cockpit Readiness (25% of force at RS05), to be ordered by the AOC-in-C in the face of “imminent risk” of attack.

[23] Twigge and Scott, *Planning Armageddon*, 296.
[24] Roger Dunsford, Vulcan Captain; email, amongst documents/text provided: 19/11/20.

The 25% (probably more like 30% in actuality) consisted of those aircraft covering "Flight Alert Targets" (priority targets). Squadron and Flight Commanders were required to ensure continuous coverage of Flight Alert Targets whilst Alert Condition 1 applied. This was to be done by rotating crews and aircraft. Remaining aircraft were required to adopt the highest state of readiness compatible with adequate crew rest periods, "in order to maintain maximum possible cover on remaining targets".[25] Alert Condition 1 was not exercised *en masse*, probably as this would have involved prolonged dislocation during exercise conditions (i.e. in the absence of "imminent risk").

By 1961 the missile threat prompted Bomber Command's then AOC-in-C, Air Marshal Sir Kenneth Cross, to extend the RS15 QRA system, as applied to SACEUR-assigned Valiants and the Thors, to the entire MBF from January 1 1962. However, his plans to double QRA force size were thwarted. The SACEUR Valiant QRA force increased from three to four aircraft and the RAF Germany SACEUR Canberra QRA doubled, from four to eight aircraft, but ambitions for an enlarged MBF QRA came to nothing.[26]

Adopting the fighter spirit

It took time for appreciation of the value of every second of warning to sink in, as shown by an incident recounted by Andrew Brookes (2001): "In 1958, the Vice Chief of the Air Staff, Air Marshal Sir Edmund Hudleston, commenting on the efficiency of Bomber Command at a Pathfinder Association dinner, revealed with pride that, in a recent surprise alert, the time from bunks to getting airborne in a V-bomber at night had been 11 minutes."[27] Things had to change. On January 24 1961 AOC-in-C Bomber Command's office sent a letter to the Under-Secretary of State (Director of Operations, Bomber and Reconnaissance), Air Ministry, explaining that Headquarters, High Wycombe, had been studying the growing threat from Soviet missiles and the accompanying "drastic decrease in tactical warning time … Against missiles, the present plan for holding the force at 40 minutes' Readiness until the first

[25] AIR 2/17801, "BCAR plan – Alert Conditions and Readiness States," Appendix A to a letter from Group Captain A. Frank, for SASO, Bomber Command, to Headquarters, No.1 Group, August 18 1961 (BC/S.96237/Ops.).
[26] Wynn, *RAF nuclear deterrent forces*, 334-335.
[27] Wing Commander Andrew Brookes, "V-Force operational deployment and readiness", RAF Historical Society, *Journal 26* (2001): 54-66.

tactical warning is received is inadequate and it is essential to be able to hold as much of the force as possible at Cockpit Readiness."[28]

This last remark was extremely significant, heralding the introduction of the new Alert Condition 1 later that year. This provided for an element of 24/7 Cockpit Readiness - the ultimate MBF Ground Alert:

> … it should be possible to hold about one-third of available aircraft at Cockpit Readiness for about seven days. It should also be possible to hold serviceable Thors with gyros running for a similar length of time and, with fully modified missiles, this would allow a launch within 10 minutes of the order. These plans will not affect the ability to hold all the bombers at Cockpit Readiness and the Thors fully fuelled for a matter of hours, should the situation so demand.[29]

The pace of change accelerated. Several senior V-Force posts went to officers with fighter backgrounds, so as to instil Fighter Command's tradition of quick reaction. This began some years before. Air Chief Marshal Sir Harry Broadhurst, with an illustrious World War 2 fighter record, became AOC-in-C Bomber Command in January 1956 and played a significant role in steering change. Kenneth "Bing" Cross, with an air defence background, was given No. 3 Group (1956) and went on to become AOC-in-C (1959). The V-Force personality began to change. At a July 21 1958 meeting, Minister of Defence Duncan Sandys approved proposals "to enable the bomber force to come to Readiness at weekends and holidays no less rapidly than during the week." It was also agreed to "make it possible to bring the force to 15 minutes' Readiness for a week in an emergency." In addition, six more dispersal airfields were added to the list of 24 already agreed. This meant that only four (rather than eight) aircraft would be left on each main base after dispersal. Secretary for Air George Ward was invited to "report on what could be done to keep part of the force at 15 minutes' Readiness for longer than one week" in an emergency.[30]

In the early Summer of 1959 the Minister of Defence visited RAF Cottesmore. During this visit he asked for a report on MBF Readiness. This was ready by July 1 and its summary claimed:

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[28] AIR 2/17801, letter from Group Captain A.D. Frank, for AOC-in-C, Bomber Command, to the Under-Secretary of State (D. of Ops. (B&R)), Air Ministry, January 24 1961.
[29] Ibid.
[30] AIR 8/2238, "Readiness of Bomber Command", meeting of the Minister of Defence with the Secretary of State for Air, July 21 1958.

> Considerable progress has been made during the past year in increasing the retaliatory power at Bomber Command. A coordinated Bomber Command/SAC strike plan has been worked out in detail and is now effective; crews are briefed and trained on their pre-assigned targets for both unilateral and coordinated plans. Eleven more dispersal airfields have become available for use and equipment is being pre-stocked on them. Most aircraft have been modified and equipped to carry two types of British weapons and US weapons; there is now a weapon for every operational aircraft. The force as a whole has been exercised in dispersal and Readiness, including weapon preparation.[31]

The new decade, however, opened with doubts about the value of investing in faster take-off times for the V-Force, given the scale of the missile threat and the prospect of exposure to strikes from Soviet submarines positioned off the west coast (Fylingdales' aerials were trained east). In July 1961, then Air Chief Marshal Sir Thomas Pike wrote to the First Sea Lord, Admiral Sir Caspar John, asking for his support for V-bomber modifications for, *inter alia,* more rapid take-off:

> I would not dissent from the view expressed by the JIC that by 1964 missiles fired from submarines could do so from sectors not covered by Fylingdales… Whether or not the Russians would use missile-firing submarines against the UK seems to me more problematical, particularly at a time when they do not have parity of weapons with the USA. The submarine gives them the only means of striking the USA without giving some 20 minutes of warning time. Indeed, in the light of the JIC's own assessment of the probable progress of the Russian submarine building programme (35 missile-firing submarines by 1964), I believe we must expect any attack on the UK to come mainly, if not solely, from aircraft and land-based missiles… I am certain that we cannot afford to disregard either the land-based missile or the manned aircraft threat. To counter the first of them, the V-bomber modification programme is of first importance.[32]

Disperse to survive

There was more at stake than aircraft modifications. There were concerns over the recently-approved V-Force dispersal plan. In the background was a rather defeatist (and incomplete) argument over the missile threat and V-bomber vulnerability – that given the V-Force was so exposed to destruction, it might as well be destroyed on its main bases and a few dispersal airfields, rather than meet the costs of the full dispersal plan. The debate was muddied by those still optimistic enough to back planning for multiple strikes, rather than just one retaliatory sortie. Some years before, in late 1955, a meeting chaired by the CAS had discussed dispersal against the background of planning for three strikes by a diminishing V-Force, but with only one

[31] AIR 8/2238, "Progress report on the readiness of the MBF", July 1 1959.
[32] AIR 8/2238, letter from Air Chief Marshal Sir Thomas Pike to the First Sea Lord, Admiral Sir Caspar John, July 11 1961.

strike from the dispersal airfields, due to the impracticalities of providing for three full strength strikes from each airfield, "when we clearly could not be certain either of the distribution of casualties throughout the force or which airfields might be useable." This implied follow-up strikes from main bases only – despite the fact that these were obvious priority targets and, therefore, unlikely to be useable. Logically, as the missile threat matured, there could be only one retaliatory strike. Yet, planning in the mid-1950s envisaged three lifts – a total of 366 sorties, in lifts of 150, 120 and 96. A subsequent initiative considered the second and third lifts flown from 12 specially-prepared dispersal airfields. As for dispersal prior to war, the pre-missile era plan was for one squadron to operate from each Class I airfield, the rest of the force dispersing in units of four aircraft. This process was to be completed within 72 hours, with as many bombers as possible brought to 40 minutes' Readiness.[33]

An earlier intention, to operate the entire MBF from 10 Class 1 main bases, carried the obvious risk of wholesale destruction on the ground.[34] This led to the dispersal plan (originally 10 main bases and 45 other airfields) approved by the Air Council in June 1955. In later years, reduced V-Force size led to a corresponding reduction in the number of dispersal airfields. Vulcan Nav/Radar Roy Brocklebank describes the lack of resources surrounding this issue:

> The whole dispersal plan was the brainchild of "Bing" Cross. A huge amount of money had been spent on Bloodhound missiles to protect the Thor sites and the main bases, in addition to, of course, building a bomber fleet. I believe he was then told that there was no money for his dispersal plan. He said he could do it and forged ahead with austere dispersals. Some used existing buildings, such as the complex at Ballykelly; others used caravans, such as the five-berth ones at Pershore. At some, the accommodation was at the opposite end of the into-wind runway (Brawdy). He must have found the money somewhere to get the ORPs built.[35]

During long-winded debates about the level of dispersal required, cost remained the driver. T.C.G. James (1987) set out a major problem on this front:

> The issue here was how far precautionary measures could go in the interest of effective deterrence, without running into the objection that the objective of expenditure was to avoid war, not to fight it. For the Air Council, this was a genuine issue, and not least because the Treasury was the unseen presence at all its deliberations."[36]

[33] AIR 20/11554, "A note on the dispersal and operation of the MBF," referencing a CAS meeting on November 23 1955, C.M.S. 2518/D.D. Ops (B).
[34] AVIA 65/43, "The development of the MBF", November 2 1954.
[35] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 16/4/19.
[36] AIR 14/86, James, "The RAF in the postwar years", 105.

In an ideal world, there would be only one bomber per dispersal airfield, but there were practical as well as financial limits – the number of suitable airfields was finite (as was the number of crews available to sustain Cockpit Readiness for a proportion of the aircraft).[37]

In searching for suitable dispersal airfields, the planners took in areas in the UK north and west providing slightly longer missile warning. Dispersals were classified as "Near" or "Far" from main bases. The former could be serviced by road, but Far Dispersals required air transport support.[38] By early 1960, there were nine Class I airfields: Marham, Waddington, Finningley, Cottesmore, Scampton, Coningsby, Honington, Wittering and Gaydon. In addition, 30 dispersal airfields were planned, of which 16 were available at that time. By 1963, there were seven main bases (Finningley and Gaydon became OCUs):

- **Waddington:** Brawdy (2 aircraft), Prestwick (2), Finningley (4), Filton (2), Machrihanish (2), Valley (2).
- **Scampton:** Burtonwood (4), Lossiemouth (2), Elvington (2), Kinloss (4).
- **Coningsby:** Yeovilton (2), Llanbedr (2), Bruntingthorpe (2), Ballykelly (4).
- **Cottesmore:** Boscombe Down (2), St. Mawgan (2).
- **Honington:** Bedford (4), Gaydon (4).
- **Wittering:** Pershore (2), Lyneham (2), Wyton (4), Leuchars (2).
- **Marham:** Cranwell (2), Coltishall (2), Manston (2), Wattisham (2), Leeming (2), Leconfield (2) and Middleton St. George (2).

This provided for dispersal of 72 aircraft from main bases, with four each (28 in all) remaining on the former (36 airfields; 100 aircraft). It was accepted that, for unserviceability and other reasons, it would be impossible to achieve 100% generation.[39]

Dispersal encouraged the Soviets to allocate more weapons, but gave small flights of dispersed aircraft a better chance of surviving a war scramble (especially flights

[37] AIR 20/11554, "V-bomber and PR force dispersal: completion of the V-bomber dispersal plan, dispersal of the PR force and implications of second and third bomber lifts", Air Council note by VCAS and AMSO, February 4 1958 (A.C. (58) 7).
[38] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 5/4/20.
[39] AIR 2/16435, "Allocation of dispersal airfields for the MBF", loose minute from Air Commodore A.W. Heward, D. of Ops. (B&R), to ACAS (Ops.), March 1 1963.

limited to two aircraft). Assuming dispersal was ordered, they would not be caught in take-off queues on main bases. ORPs facilitated rapid take-off, with aircraft advantageously positioned for scramble. Previously, ORPs were confined to fighter airfields.[40] Dispersal, however, made for more difficult point defence – involving a larger group of airfields with a much wider geographic spread. Conflict might well begin with a period of conventional warfare and the only counter to repeated conventional raids would be repeated "survival scrambles", but this did not feature in major exercises, according to Nav/Radar Roy Brocklebank: "Certainly, in the 1960s we never considered the question of survival scrambles. Also, when a Micky Finn was called, we always refuelled to minimum fuel for flight to dispersals. We would have been unable to fly a war mission".[41]

Tony Cottingham, a Valiant Pilot, remembers occasional dispersal exercises "when we flew to airfields which were not V-bomber bases … we would have three or four aircraft parked on a Readiness dispersal near the crew quarters, to be at 15 minutes Readiness to scramble, for about two days. There could be a call, at any time, to come to five minutes' Readiness."[42]

Dispersal was complicated by American "E" weapons arming Canberras and some heavier aircraft, notably SACEUR's TBF Valiants. The fundamental problem was dual control. E weapons and their American custodians were based at only a few stations; one consequence was the concentration of all three TBF Valiant squadrons at Marham, which increased the risk of destruction on the ground. In mid-1958, the AOC-in-C Bomber Command was warned that refusal to release, or a delay in releasing, E weapons could make it impossible to disperse aircraft.[43]

Project E was active until 1965 in Bomber Command (1969, in the case of RAF Germany). The problem of custodial arrangements and dispersal ended in relation to main force Victors and Vulcans in March 1962, with the arrival of sufficient British Yellow Sun 2 megaton weapons. During the life of the E programme, three Special Storage Areas (SSAs) – at Honington, Marham and Waddington – were occupied exclusively by E weapons. The UK weapons had to be stored at remaining Class I airfields and depots. An appreciation of Project E noted: "In consequence, UK

[40] Wayne D. Cocroft and Roger J.C. Thomas, *Cold War: building for nuclear confrontation 1946-1989* (Swindon (UK): Historic England, 2016), 27.
[41] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 21/4/20.
[42] Tony Cottingham, Valiant Captain; interviewed: 8/2/18.
[43] Wynn, *RAF nuclear deterrent forces*, 262-263.

weapons are not in the best locations to meet the unilateral strike plan, in which aircraft from E stations must be used. Moreover, Yellow Sun weapons must be held at greater concentration than is desirable …"[44]

Certainly, American E weapons were a mixed blessing. A letter of August 4 1959 from A/ACAS (Ops.), Air Commodore P.G. Wykeham, to the VCAS, Air Marshal E.C. Hudleston, noted that, with three SSAs now given over to E weapons and no SSA at Scampton, the only stations on which UK weapons could be held alongside the aircraft were Wittering, Cottesmore and Finningley. "If we consider the case of an enemy attack with a very short period of warning, any delay in releasing E weapons could mean that less than half of the MBF could be rapidly brought to Readiness."[45] In July 1960, the Air Council agreed the gradual phase-out of Project E, but it lingered for years.

Exercise EDOM

Immediate response on QRA was practiced in "Exercise EDOM". Vulcan Nav/Radar Roy Brocklebank described QRA handover: "The first question an incoming crew would ask was, 'When was the last practice called?' If it had been more than 24 hours, we would be on edge until the alert was called. As soon as the Tannoy clicked and the magic words 'Attention. Attention' rang out, the crew were running."[46]

Naturally, the nervous release of a practice alert failed to banish deeper stress. Sometimes there would be a second alert within five hours. Roy Brocklebank recalls that, on occasion, it was a case of "more haste, less speed":

> … to get the shortest reaction time possible, the Crew Chief would start the engines from outside the aircraft before opening the cabin door. Then the unthinkable happened at Waddington on a Mk. 1A. When he was standing on the nosewheel and at full stretch, the key broke off in the lock. There was the nuclear-armed bomber, fully fuelled, engines running, ready to go and the crew standing outside, looking on. How long could it run at ground idle before running out of fuel?[47]

On dark Winter nights, QRA call-out could feel like torture:

[44] Ibid, 263-264.
[45] Ibid.
[46] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter: amongst documents/text provided: 25/6/20.
[47] Ibid.

> Despite the likelihood of having to go in during daylight, we had regular call-outs at around 4 am. We saw this as needless buggering about. While this was the 'Tripwire' period, we believed we would have some warning during a build-up of tension, rather than finding ourselves suddenly going straight into a war.[48]

Life on the nuclear frontline had moments of acute tension. Crews were conditioned to follow procedures to the letter; Victor Pilot Gary West remembers that any departure from "normal" was most unwelcome:

> On a wet and cold Winter's afternoon I was on QRA with the crew when the siren sounded. We went to cockpit readiness and then to 02, so we taxied to the end of the runway and I saw the XV Squadron aircraft move into position on our starboard side. It suddenly dawned on us that no-one had heard the Bomber Controller use the correct codewords: "Exercise EDOM". There was a frightened silence followed by a flood of expletives. After 10 minutes or so, we returned to Readiness 15 and, heaving a sigh of relief, taxied back to the pan. The Bomber Controller had fouled up. He'd forgotten to transmit the codewords.[49]

Nav/Plotter Robin Woolven stood QRA at Scampton, with three Blue Steel-armed Vulcans ready to go: "The boredom was relieved by the alerts – Exercise EDOM. Our QRA aircraft would never taxi with Blue Steel, given the hazards of HTP."[50] Victor Nav/Radar Norman Bonnor remembers the "clapped-out" Standard Vanguards used for QRA crew transport at RAF Cottesmore: "They were terrible – ancient staff cars, often beyond the point of roadworthiness."[51]

Roy Brocklebank reflected on the variation in QRA routines between the squadrons:

> On most squadrons each crew began a period of QRA standby at 9 am, after the Station Morning Briefing – "Morning Prayers". They would then go to their designated aircraft, remove the previous crew's flight kit, check the target Go-Bag and the weapon and return to Operations for light duties, such as Target Study or flight preparation for their next training mission. The off-going crew would either stand-down or perhaps fly. On my squadron, we had a different deal. Each crew did either a 48-hour duty during the week or a 72-hour duty at the weekend, followed by a 24 or 48-hour stand-down. This rotation meant we did QRA less frequently and with less disruption to family life.[52]

[48] Ibid.
[49] Gary West, Victor Co-Pilot, 10 Squadron, RAF Cottesmore; 55 Squadron, RAF Honington; Captain, Victor tankers, RAF Marham; interviewed: 28/3/18.
[50] Robin Woolven, Vulcan Nav/Plotter; documents/text provided: 5/11/20.
[51] Norman Bonnor, Victor Nav/Radar; documents/text provided: 1/11/20.
[52] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; documents/text provided: 25/6/20.

He described his longest QRA duty: “We did it over an Easter Bank Holiday, 9am Thursday until 9am the following Tuesday. Five days was just too long.”[53]

Every variation in QRA rota design had its champions, as Nav/Radar Norman Bonnor recalls: “On XV Squadron… we had 10 crews and, at any one time, one crew would be fresh and yet to be declared combat-ready. Another crew would be on leave and, perhaps, a third would not be available for a variety of reasons. We favoured four-day (Monday-Thursday) and three-day (Friday, through the weekend) QRA duties. This meant QRA duty came round every three weeks. The system worked well and we stuck to this regime. On 100 Squadron, however, a 48-hour regime was in place: Monday-Tuesday, Wednesday-Thursday and Friday plus the weekend. It seems each squadron found its own solution.”[54]

Whatever solution was found, crews soon discovered that manning the nuclear frontline dominated their personal lives. If away for more than five hours, they had to ensure the Station knew where to reach them. They had to be able to return to base within 24 hours. There were constant reminders of the primary purpose of the V-Force and its association with Armageddon. Roy Brocklebank acknowledged that, to some extent, personal lives were surrendered:

> We were required to enter contact details in the Squadron Recall Book. If we were likely to be away from our stated locations for more than 16 hours, we were required to ring Operations with fresh contact details. Later, if going away, we had to put our location in the Squadron Recall Book.[55]

They moved to RAF Cottesmore in the Autumn of 1964:

> My hut was close to the Ops. Block. When there was a call-out, I would check in, grab the Squadron Recall Book and get to work on the telephone. We used a “cascade” system. I’d call someone, who would then call others nearby, or on his route into the base, and so on. We were required to have at least five complete crews on the Station within one hour of the hooter going, allowing for the generation of our QRA spare. Waddington, meanwhile, was required to despatch by road four crews to RAF Finningley, to man OCU aircraft.[56]

[53] Ibid; email: 5/4/20.
[54] Norman Bonnor, Victor Nav/Radar; documents/text provided: 1/11/20.
[55] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; documents/text provided: 25/6/20.
[56] Ibid.

To summarise, this chapter recognises UK Ground Alert as the only viable MBF posture. Airborne Alert lacked viability - although some politicians were content to tout an Airborne Alert capability which did not exist. The mathematics allowed no room for argument: one aircraft in the air required 3.8 squadrons to support it and, for much of the 1960s, the V-Force consisted of just 11 squadrons. Equally, dispersal to remote locations overseas also lacked viability without a long range stand-off weapon. Setting aside political and logistical issues, the available tanker support was insufficient to provide the required target cover. UK Ground Alert was MBF's sole option. Against this background, the crucial decision was taken in 1961 with the adoption of Alert Condition 1 (providing Cockpit Readiness to the maximum extent). The adoption of QRA at RS15 the following year did not conflict with Alert Condition 1, as frequent calls to RS05 Cockpit Readiness (or higher alert states) were central to QRA exercises but without the extensive disruption a large-scale Alert Condition 1 exercise would cause. Alert Condition 1 represented maximum effort, as there were insufficient crews to double-man more than 30% of the generated and dispersed V-Force. If double-manned aircraft were held at RS05, with all cockpit checks completed and the crews poised for RS02 (engine start), this would allow a few aircraft to survive simultaneous launch, low trajectory IRBM strikes on their airfields.

– 6 –

VULNERABILITIES ON THE GROUND: GENERATING WEAPON SYSTEMS

The complexities of UK Ground Alert are further reviewed in this chapter, with a closer look at the most significant response to MBF vulnerability on the ground: the ability to hold a proportion of the V-force at 24/7 Cockpit Readiness in the context of imminent threat of attack. This posture – Alert Condition 1, introduced in 1961 – is discussed in more detail, as it is fundamental to the central argument of this thesis: that a core retaliatory threat was maintained during the 1960s. This chapter also considers the difficulties surrounding the generation, dispersal and regeneration of weapon systems.

Home truths

The Defence Board met at the Treasury on April 4 1960 to discuss unpleasant realities surrounding the new strategic environment: mass deployment of nuclear missiles by East and West. Those present included Harold Watkinson, Minister of Defence, Duncan Sandys, then Minister of Aviation, and George Ward, Secretary for Air. The main business was V-Force vulnerability; both Sandys and Ward had prepared papers for consideration. Major concerns included the future of the deterrent and the relative merits of a Skybolt-armed V-Force and the Blue Streak ballistic missile.[1]

Blue Streak, a surface-launched, liquid-fuelled weapon, was as vulnerable as the American Thors. Sandys said the military case for Skybolt rested largely on the claim that the V-Force was less vulnerable to Soviet first strike than Blue Streak. He told the Board that if invulnerability was militarily essential, V-bombers were just as vulnerable as Blue Streak and, therefore, were also a "fire first" weapon (whilst conveniently ignoring "positive control"). He argued that, with no strategic warning, V-bombers would be concentrated on their main bases, representing only three separate aiming points for a Soviet attack with 3MT missiles (then in prospect, rather than in service). The document setting out the meeting's conclusions noted that if

[1] DEFE 13/306, "Vulnerability of the V-bomber force," conclusions, meeting of the Defence Board, April 4 1960.

such missiles were fired in low trajectories, “it was agreed that the whole V-bomber force would almost certainly be destroyed on the ground.”[2]

George Ward’s contribution also lacked balance. He argued that, according to the JIC, a bolt from the blue attack was unlikely. During a period of rising tension, the V-bomber force would be redeployed across 36 main and dispersal airfields and brought to a high standard of Readiness, which could include keeping part of the force on Airborne Alert. The Air Staff supported Ward’s claims for Airborne Alert and, looking ahead, suggested that an Airborne Alert of 20% of the total force, with each aircraft armed with two Skybolts, would constitute “a significant deterrent”. These claims are interesting, given that Bomber Command studies had already demonstrated, convincingly, that Airborne Alert lacked feasibility. As for Ground Alert, just two years later Macmillan would decide against V-Force dispersal, during the very real threat of nuclear war over Cuba.[3]

Sandys claimed 50 Soviet missiles could destroy virtually the entire V-Force, even if dispersed, unless crews were at cockpit readiness. The Air Staff felt otherwise, telling only part of the story by arguing that four V-bombers could already scramble in four minutes and that this time would improve with Mk. 2 aircraft and SIMSTART. Sandys went further, claiming that 250 Soviet missiles would be enough to destroy 80% of V-bombers, on the ground or in the air, even if crews were in the aircraft, with engines running. Once again, the Air Staff disagreed, continuing to avoid the full picture and pointing to the possibilities of Airborne Alert and of dispersing V-bombers more widely in the UK or even to remote bases overseas. This ignored the obvious political and logistical problems of overseas dispersal and lack of target coverage without refuelling (highlighted only six months before in a Bomber Command study). As for heightened Readiness on Ground Alert, to reduce exposure to missile strike, 20 V-bombers held permanently at Cockpit Readiness would be extremely costly, requiring a 50% increase in aircrew and force frontline strength.[4] This ignored another possibility: round-the-clock RS05 deployment of part of the V-Force, double-manned in an extreme emergency (which was to form the basis of a new Alert Condition 1 the following year).

[2] Ibid.
[3] Ibid.
[4] Ibid.

In the final analysis, V-Force credibility centred on just one number: how many bombers would survive a war scramble? Here, the Defence Board considered information from the British Nuclear Deterrent Study Group and the Joint Inter-Service Group for the Study of All-out Warfare. This was pessimistic about the bombers' chances of getting away, given capabilities at that time and the possible use of 3MT low trajectory weapons. It was estimated that aircraft on the ground had to be six miles from Ground Zero (three miles in the air) to survive. This was not based on actual megaton burst data but, rather, a scaling up of data on kiloton bursts. A Defence Board Secretariat note observed: "Allowing for the detection of a Soviet missile and the communication of the information to the bomber stations (25 seconds), for the bombers to start take-off and get their 'wheels up' (70 seconds) and for the aircraft to fly clear of a 3MT burst on their base (60 seconds), the total time required between first radar pick-up and a bomber being safely in the air is two minutes 35 seconds." This assumes, however, no delays and that all crews are at RS02, with engines running and positioned for take-off, when warned of incoming weapons. A 1,000NM low trajectory missile could mean less than four minutes between detection and detonation. According to the Defence Board Secretariat: "On this timing (which assumes that all procedures work perfectly and the aircrew are at cockpit readiness), only the first bomber taking off from each of the 36 dispersal airfields could get safely away: the succeeding bombers would be caught either on the ground or within the lethal distance from the burst on their base."[5]

Yet, armed with a set of highly favourable assumptions, the Defence Board Secretariat still put a brave face on things:

> Nevertheless, the successful launching of 36 bombers would represent about 50% of the available frontline of Mk. 2 V-bombers, on the current Air Staff assessment that 70% of the frontline would be serviceable at any one time. The achievement of these timings will, however, require considerable improvement in the take-off timings and procedures of the V-bomber force: in a recent Air Ministry exercise, six minutes were required to launch successfully 50% of the participating force.[6]

Expectations look over-optimistic, regardless of the closing qualification. Whilst the Soviet weapons considered were not yet deployed, this outcome relied on a long list of favourable circumstances: dispersal, fast regeneration, prompt Command

[5] DEFE 13/306, "Vulnerability of the Bomber Force," note by J.M. Wilson, Defence Board Secretariat, April 4 1960.
[6] Ibid.

decision-making, swift verification of early warning, faultless communications, immediate reaction and a swift response from crews *already in the cockpit and ready to go*. It was possible for four aircraft to get off in one minute 45 (or even slightly faster), but crews had to be in their cockpits, with engines running and favourably positioned for take-off. Even then, many would have been destroyed or damaged by incoming missiles. Measures such as QRA and SIMSTART optimised the scramble response, but nothing changed the mathematics, should the Russians opt for a low trajectory surprise attack on the airfields. The V-Force was vulnerable even when dispersed and cockpit ready. There was, however, that one option (referred to above – part of the force held continuously at RS05) which would increase the chance of one or even two survivors from some airfields. Assuming dispersal and regeneration of flights of two or four aircraft, it would have been possible to keep at least one aircraft at RS05 (up to the very point of engine start), by rotating crews in a much expanded, extreme form of QRA - the highest possible Ground Alert Readiness State.

The note from the April 1960 Defence Board meeting, together with the conclusions of the March 1962 Bomber Command ORB memorandum (No. 241) on MBF exposure to missile attack, look relatively realistic when set against claims made a decade later. In 1971, consideration of a future air-delivered system formed part of the Long Term Strategic Nuclear Working Party's review of options for a Polaris successor. The Air Force Department contribution to this study took an extraordinarily optimistic view of V-Force survivability at launch: "… scrambles are regularly practiced and the average time achieved over the last eight years by the fourth aircraft is one minute 53 seconds." There was no acknowledgement of the significant time required to reach the point where scramble is possible. Equally, there was no mention of the relatively poor prospects for survival identified in past years. On the contrary, the Air Force Department declared: "Studies carried out some years ago, and since updated, show that the chances of scrambling aircraft escaping the effects of incoming nuclear missiles are very high; even assuming the minimum warning time they are of the order of 92 to 94%."[7]

This Air Force Department paper relied on an assumption of simultaneous impact attack, rather than simultaneous launch. It made a dubious claim: "This situation of four minutes' warning from BMEWS is pessimistic, in that it assumes the UK being

[7] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department paper to the Long Term Strategic Nuclear Working Party, Interim Report, September 30 1971.

attacked first or in isolation, thus giving the United States positive collateral of nuclear strikes – a strategy unlikely to be adopted by the Soviet Union."[8]

Once again, all underlying assumptions are favourable: crews in cockpits and ready to go, with aircraft fully-fuelled and dispersed as planned. By 1971, the pressure was off to some extent, as Polaris occupied the strategic frontline. Furthermore, the purpose of the Air Force Department paper was advocacy of a *future deterrent* based on manned aircraft. This might explain the 92%-94% survivability claim for the existing bomber force. In fact, this paper wanted it both ways. Despite a rosy assessment of the current ability to escape missiles (even given a decade of exposure to the SLBM threat), the paper continued:

> If a future air delivery system were to be decided upon as the main national deterrent, there would be a need to revive a ground-based QRA and, as such a system would not be viable if missiles were launched from submarines close to the United Kingdom, there would also be a requirement for progression to an "Airborne Alert" state.[9]

This is a curious conclusion: ageing Vulcans had no need of Airborne Alert, yet Airborne Alert would be essential for a future air-delivered system. Past studies drawing negative conclusions on RAF Airborne Alert were ignored (although, of course, a new system could be purpose-designed with the latter in mind, given a sufficiently generous budget).

The V-bombers' fundamental flaws included Britain's relatively close proximity to Russia, together with the 10 minute gap between RS15 and RS05 (Cockpit Readiness) and the small size of the force. In contrast, SAC had a large force of long endurance heavy bombers well suited to Airborne Alert. Viable Ground Alert required sufficient strategic warning for the generation, arming, dispersal and regeneration of the bombers, which might take several days to complete in full. Once dispersed and Combat Ready, crews would be at RS15 with, perhaps, a proportion at RS05 (Cockpit Readiness, ready for engine start and taxi). Assuming a BMEWS four-minute warning, the ideal Readiness State immediately prior to this warning would be for the first aircraft of each RS05 dispersed flight (manned by rotation) to be poised for RS02, for immediate engine start, take-off and with an ability to reach escape distance within four minutes (although even this might still not be enough to escape SLBMs).

[8] Ibid.
[9] Ibid.

The core problem was that RS05 (with all checks complete up to the point of engine start) could be held for only a few hours without crew rotation and, therefore, 24/7 RS05 could involve only a proportion of the force (say 25-30% at best) at any given time. There were insufficient crews to double-man the entire force. Furthermore, in a practical sense, *any attack would be a bolt from the blue*, as scramble required verified detection of missiles in flight. It is possible that, on the brink of war, crew rotation to maintain part of the dispersed force at RS05 (held at those dispersal airfields offering the longest warning time) might yield a modest increase in survivor numbers. Equally, in the absence of commonly applied favourable assumptions, there might be no survivors.

It seems the best that could be done, in a time of grave threat of war and given a dispersed force of 80 bombers armed and fuelled, would be to man, say, 30% (c.24 aircraft) at the highest possible sustained Ground Alert Readiness (RS05 Cockpit Readiness, with all checks complete and poised for RS02 engine start). A significant number of aircraft would escape given a 15-20 minute "American warning"/simultaneous burst attack, or a few of the "first in the queue" bombers in a four-minute warning/simultaneous launch attack – given that missiles would not arrive simultaneously but, rather, over a period of some two minutes. The minimum time required for survival, from RS05/ready for RS02 engine start, would have been around five minutes: perhaps 1½ minutes for the warning to be processed, verified, communicated, scramble order given and allowing for a brief airfield delay; 1½ minutes for engine start, verification of the scramble order, taxiing and positioning for take-off; one minute for take-off; and one minute to fly clear of missile detonation. It was ABSOLUTELY ESSENTIAL, if any bombers were to survive, that a proportion were manned by rotation at RS05, poised for RS02, on geographically favoured dispersal airfields, as it took crews at RS15 an average of around eight minutes to reach RS02 "wheels rolling"[10].

RS02 – *with engines running* – would eat into mission fuel. RS05 was limited usually to five hours (with the crew confined to the cockpit). RS02 engines running could be held for only around 30 minutes at best. In the case of aircraft with deep penetration targets, the fuel reserve (fuel available above the recovery base) would be as low as

[10] AIR 14/4327, Bomber Command, Operational Research Branch, Memorandum No.258, "The Quick Reaction Alert in Bomber Command", October 1962.

4,000 lbs. Holding at RS02 engines running for any length of time would eat into this meagre reserve – 4,000 lbs, spread over 14 tanks, was the bare minimum. Fuel was always a worry, recalled Vulcan Pilot Edward Jarron, "but I can say that crews were *not* briefed on one-way missions. Every mission had an allocated recovery base."[11] Yet some V-Force veterans clearly recall, at some stage, being briefed for targets offering no chance of recovery. Those largely sharing Air Commodore Jarron's view include Vulcan Nav/Radar Roy Brocklebank: "… the RAF did not plan one-way missions and made detailed plans for recovery … Bomber Command's War SIOP 1st Edition went into much detail on recovery, much of which was omitted from the 2nd Edition. The 2nd Edition still had recovery details, with half-hourly IFF (Identification, Friend or Foe) code tables …"[12] Yet, Brocklebank concedes that the crews of two Vulcan squadrons in Cyprus *were* briefed for war sorties requiring bale-out after weapon release. Brocklebank, when Wing Targeting Officer at Waddington, provided every target folder with a number of suitable alternative airfield approaches, although this went beyond the stated requirement for target folders.[13]

Vulcan Captain Peter Moore recalls the mood of fatalism at the time:

> While official policy was that there were no one-way targets, the practical situation was different. My crew took the view that everything was one-way. We would only be airborne post recognition of a Soviet attack which, most likely, would take out our landing options. We also didn't expect much of the UK to remain in a recognisable state and our families would most probably have been killed. For my deep penetration target, our designated recovery base was Yeşilkőy (Istanbul). However, to get there we needed to climb soon after weapon release. Collectively, we decided that that was signing our own death warrants. We were going to push on as far as we could at low level, to avoid detection and provide a minimum target opportunity for the defence. While never really believing that we would ever be launched, we reckoned there would be nothing to come back to, anywhere.[14]

This comment is amongst many from veterans which, taken together, represent solid evidence of a failure to brief crews on the likely fatal consequences of staying low immediately after weapon release.

Generating aircraft and weapons

A fully-fuelled and armed V-bomber and crew, combat ready and at RS15, represented the tip of a very large iceberg. This weapon system required a vast effort

[11] Edward Jarron, Vulcan Pilot, Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[12] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 4/12/19.
[13] Ibid; email: 22/3/21.
[14] Peter Moore, Vulcan Captain; email: 18/3/21.

by technical staff, groundcrew, armourers and other specialists. Readiness involved so much more than flying. Ground teams strived to meet demanding time targets for aircraft and weapons generation. “Exercise Mick” challenged main bases to generate weapon systems within required timeframes. “Exercise Micky Finn” went further, requiring dispersal of the entire V-Force. “Exercise Kinsman” tested dispersal at the squadron level. There were also “Mayflight” exercises. In May 1963, “Mayflight VI” saw Bomber Command achieve full generation and dispersal for the first time. VCAS W.H. Kyle recorded the results: “Of the 115 weapon systems available for the exercise, 105 (91%) were generated within eight hours and 100% within 15½ hours.” The intention was to disperse 52 weapon systems and all had been dispersed within nine hours 40 minutes. All had regenerated within 16 hours 25 minutes.[15] Scampton did not participate in full as it was engaged in Blue Steel trials.

“Mayflight VI” began with a call for force generation, followed one hour later by the order to disperse. Results were an improvement on Mayflight V (1962). During Mayflight VI, the practice Readiness States were called three times to Cockpit Readiness (RS05) and Take-off Readiness (RS02). A somewhat reduced Thor missile force took part simultaneously (“Exercise Redouble”); of the 45 missiles available, 44 were counted down to launch at the conclusion. The remaining missile had guidance trouble.[16]

Regular exercises were the essence of V-Force life. “Exercise Mick” was called on August 25 1963 as a no-notice generation test. This eight-hour drill was called on a Sunday and the outcome was described as “impressive”. The generation of 65 live weapon systems was expected and 64 (98%) were ready in eight hours (19 aircraft in two hours, 37 in four hours and 57 in six hours).[17]

Generating the stand-off bomb within acceptable times was a challenge and the exclusion of Scampton, a Blue Steel station, from the May 1963 Mayflight VI must have contributed to good results. During April 1964 Scampton held the second of a series of trials investigating problems surrounding Blue Steel generation. The first, on March 10, called for the generation of four Blue Steel weapon systems. The second, a few weeks later, required generation of eight systems and simulation of their “trickle dispersal”, in “Exercise Nursemaid”. At the start, seven aircraft were available – six

[15] AIR 8/2369, note by W.H. Kyle, VCAS, May 10 1963.
[16] Ibid.
[17] AIR 8/2369, minute to CAS from Air Vice-Marshal D.G. Smallwood, ACAS (Ops.), August 28 1963.

were serviceable and required only scheduled servicing to be ready for missile-loading. The seventh was unserviceable but two second-line aircraft were available and generated, for loading Blue Steels. All missiles were loaded prior to fuelling.[18]

"Nursemaid" highlighted the lengthy procedures required to make aircraft available for missile loading, despite the fact that six were serviceable from the first. There were also delays in fuelling missiles, exposing a need for scheduled fuelling prior to loading. Simulated dispersal revealed a need for more effective assessment of regeneration problems. It was decided that the next trial would involve actual dispersal. Meanwhile, of eight weapons generated, only five were capable of powered launch; the rest would have been dropped freefall. The "Nursemaid" memorandum reported:

> …the first system was declared Combat Ready 15 hours and the eighth 32 hours after the start of generation … All eight systems completed the post-load checks successfully in the powered role. The three systems which became unpowered did so because of leaks in the HTP system … The times for regeneration varied between four and 14 hours and the time from the start of the trial to the completion of regeneration varied from 26 hours 45 minutes for the first system to 45 hours 15 minutes for the second system. No times can be quoted for unpowered systems since the work carried out on these made them unrepresentative of the operational system.[19]

Clearly, Blue Steel needed more than a "nursemaid". It was not just a question of system complexity:

> Aircraft became available for missile loading between one and two hours later than planned and between four and six hours later than the times taken to generate freefall aircraft in a typical no-notice exercise. This slow rate of progress was largely the result of bringing only 50% of Line Squadron men on duty at the beginning of the trial. Lack of manpower prevented integration of scheduled work and was responsible for delays … It is considered that the bulk of Line Squadron manpower should be brought on duty at the beginning of generation … Serious delays, amounting to between five and eight hours, in starting missile fuelling occurred on five of the eight systems generated. Those delays were caused partly by moving aircraft to the dispersals on which missile fuelling was carried out and partly by shortage and poor control of fuelling teams. The division of the available fuelling teams into two equal shifts was not the best deployment for the task in hand … it is considered that a proportion of missiles should be fuelled before loading to aircraft.[20]

[18] AIR 14/4359, Bomber Command, Operational Research Branch, Memorandum No. 298, "Analysis of Exercise Nursemaid, April 14-15 1964", August 1964.
[19] Ibid.
[20] Ibid.

Freefall weapons were different. According to Waddington Wing Targeting Officer Roy Brocklebank, this station's weapons teams could load and handover a Yellow Sun 2 in seven minutes: "The Station Commander, Arthur Griffiths, was annoyed (incandescent) when the first WE.177 took about 95 minutes. As there were only six loading teams, such a slow rate would cripple his force generation times. Typically, he expected his 20 aircraft target to be met in under five hours. We got the WE.177 time down to 35 minutes."[21]

Fuel, as always, was a critical factor. Roy Brocklebank recalls that some distant targets required the fitting of bomb-bay fuel tanks: "There were three different tanks available: the Blue Steel aircraft had two saddle tanks, each of 5,500 lbs capacity. These were later available to the freefall force. Freefall aircraft with WE.177 could carry one or two drum tanks (forward or forward and aft); each contained 8,000 lbs, giving a maximum of 16,000 lbs. During generation, it was essential to generate the correct tank fit in time to be ready for the appropriate target priority."[22]

Returning to Blue Steel, many a good man refused to accept defeat in the face of the missile's idiosyncrasies. There were improvements in generation times and Readiness, yet the fact remained that many bombers on Britain's nuclear frontline carried a weapon with serious disadvantages in the "four-minute warning" world of QRA. There were always doubts, at the highest level, about Blue Steel's value as a positive contributor to V-Force operational effectiveness. A March 1966 Bomber Command memorandum reported on the operational effectiveness of Blue Steel QRA over a six-month period. This complex study was made more difficult by the "impracticability of making a post-QRA flight with a system representative of the state it was in on QRA." The work had to be based on post-QRA ground tests, together with limited checks made whilst on QRA and estimates of likely in-flight "arisings". This drew on evidence from other sources, particularly defects reported during training sorties and tests of missile system components.[23]

The mean values from post-QRA analysis (at take-off, but including some defects probably arising during the flight) gave:

- 81% probability of successful powered launch.

[21] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email, amongst documents/text provided: 25/6/20.
[22] Ibid.
[23] AIR 14/4385, Bomber Command, Operational Research Branch, Memorandum No. 326, "The likely operational effectiveness of the Blue Steel QRA force, April-September 1965", March 1966.

- 4% probability that a system, nominally powered, would fail after launch.
- 15% probability that an unpowered launch would have to be made.

Taking five QRA systems (one per squadron of eight Blue Steel aircraft), this suggested a likelihood of four powered and one unpowered system, with a small probability that one of the powered systems would fail after launch. The reality was worse:

> Adding in the estimates of likely in-flight arisings (pre- and post-launch) results in final mean estimates of 65% probability of successful powered launch, 15% probability of post-launch failure and 20% probability of unpowered launch. Once again, in terms of five systems, this means a likelihood of three systems making a powered attack, a fourth system, nominally powered, failing after launch, while the fifth system would make an unpowered attack.[24]

Given only five Blue Steel QRA systems, a change in this outcome would require "considerable alteration of individual probabilities." The causes of unpowered delivery were varied but Stentor rocket motor and autopilot failures were prominent.[25] There was no comment on how many of the five Blue Steel QRA systems would survive an attack on their bases and continue to survive until the point of attack, powered or unpowered.

The Operational Research Branch also studied the likely effectiveness of the freefall QRA force. This considered reports on aircraft after post-QRA flights or after periods on QRA standby not followed by a flight. The aim was to measure likely operational capability in a hi-lo mission. This September 1965 memorandum focused on in-service functioning of the NBS; an annex (Annex F) noted:

> Of the 137 radar bombing attacks … made on post-QRA flights over the period May 1964-April 1965, 15 (10.9%) were affected by equipment malfunctions. In normal training flights over the same period, there were 7,908 radar bombing attacks, of which 688 (8.7%) had actual (as opposed to simulated) equipment malfunctions. Although the malfunction rate was higher on post-QRA flights, the difference is not significant, since it could arise by chance three times out of 10.[26]

In a covering note to this memorandum, R.J. Monaghan, then Bomber Command's Chief Research Officer, identified the key points:

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[24] Ibid.
[25] Ibid.
[26] AIR 14/4374, Bomber Command, Operational Research Branch, Memorandum No. 314, "The likely operational effectiveness of the freefall QRA force, May 1964-April 1965", September 3 1965.

> Evidence from post-QRA flights is the more reliable and indicated major degradation of operational capability on 7.7% of occasions. Adding to this the evidence from cases where ground defects caused cancellation of the post-QRA flight brings the total for major degradation up to about 10.5%. Of this, 4% would be from before-flight unserviceability and 6.5% would be from in-flight unserviceability. NBS faults were the major cause on at least 75% of the occasions of unserviceability, with a malfunction rate during flight about the same as that encountered in normal training flights.[27]

Regardless of hardware limitations, senior officers' expectations of absolute crew commitment never wavered. Radar bombing targets for a sortie were declared pre-flight in Squadron Authorisation Books. Once airborne, crews were required to complete attacks on these targets, regardless of the state of the systems. The only exception accepted was observation of peacetime safety limitations. Crews practiced limited procedure attacks, including without computer or even without radar picture. The results, given the simulated equipment failures, were often very accurate.

Problems with Blue Steel

Blue Steel presented planners, aircrew and ground technicians with a host of problems. Bill Taylor was Co-Pilot with Sam Lambdon's crew on 27 Squadron at Scampton. They arrived in October 1963, when 27 was still a high altitude squadron armed with Yellow Sun 2. The first Blue Steels came through Scampton's gates within a few weeks; the Lambdon crew flew their first powered bomb training round in February 1964. They could launch Blue Steel from 250ft but, overall, were unimpressed: "Its serviceability was not terribly good. Mating the weapon to the aircraft raised all sorts of difficulties. 'Wet' rounds were a worry. We had a couple of high temperature incidents with HTP."[28]

Problems highlighted in later operational research studies should have come as no surprise, given the findings of a report of July 1963. "Blue Steel and QRA" reached extremely disturbing conclusions. The AOC-in-C Bomber Command ordered that this document should not to leave Headquarters, High Wycombe. The conclusions were so damning that Bomber Command's then Chief Research Officer, Tom Kerr, proposed arming QRA aircraft of Blue Steel squadrons with the new laydown freefall bomb, WE.177, when available (which it would not be, in any numbers, before early 1967 – over three years away).[29] The ultimate question was not addressed: had

[27] Ibid.
[28] Bill Taylor, Vulcan Co-Pilot, 27 Squadron; Captain, 617 Squadron, RAF Scampton; interviewed: 19/2/19.
[29] AIR 14/4341, Bomber Command, Operational Research Branch, Memorandum No. 272, "Blue Steel and QRA", July 1963.

arming 40 V-bombers with Blue Steel enhanced or degraded V-Force capability and credibility?

This significant study was made just before Blue Steel-armed aircraft joined freefall aircraft on QRA. Kerr noted that freefall QRA aircraft had been "extremely effective" in maintaining less than 15 minutes' Readiness. The memorandum reflected: "The Blue Steel weapon system… is complicated and prone to numerous defects, both on the ground and in the air. In these circumstances, the operational implications of keeping the missile on QRA with or without fuel have been examined." The findings made grim reading:

> Assuming that six weapon systems are on QRA, (serviceability data) indicates that 40%, or between two and three, will be launched at the launch point and the remaining four or three will have to be carried to the target and released from a pop-up manoeuvre … Of the missiles launched, about 75%, or two, would follow their correct trajectories and about 25% – about one – will fail before reaching the target area and will be wasted.[30]

These figures did not improve sufficiently over the next few years to make any significant difference in such a small QRA force. Furthermore, no allowance was made for losses from enemy action. Kerr did not shy away from the facts:

> Since three of the fuelled missiles will have become freefall before release, the difference in operational capability between the fuelled and unfuelled missile rests upon the difference in the probability that three freefall missiles delivered from a pop-up manoeuvre will achieve greater or lesser success than two Blue Steel missiles launched from a stand-off position relative to the target. As the biggest unknown is how much the defences will have suffered by the initial missile strikes, it is impossible to estimate, with any accuracy, the relative success. The difference is likely to be very small. Operationally, therefore, there is little to choose between keeping fuelled and unfuelled missiles on QRA.[31]

It was "strongly recommended" that, initially, QRA missiles should be prepared for freefall use only, followed by the progressive introduction of full preparation of missiles, but unfuelled, for QRA, then, ultimately, fuelled QRA missiles. Kerr, however, went further:

> The cost of maintaining a high state of Readiness with the Blue Steel weapon system and its predicted unreliability make it extremely important that the use of the laydown bomb be examined as an alternative QRA weapon system for the Blue Steel stations. The inconvenience of having aircraft on one station in

[30] Ibid.
[31] Ibid.

> two different roles must be weighed against the saving in aircraft and manpower which can be achieved, and a marked increase in the operational capability of the weapon system.[32]

In essence, Kerr was suggesting that Blue Steel was inappropriate as a QRA weapon, given its operational drawbacks and high probability of unpowered use. Why not bend to the facts and adopt an all-freefall QRA? Had this course of action been taken, however, there would have been that long wait for a non pop-up freefall weapon.

Kerr's pragmatism fell on deaf ears. Instead, the struggle to turn Blue Steel into a viable weapon system intensified. By April 1964 Bomber Command had a computer program simulating Blue Steel generation, including inputs on times for each stage of preparation and probabilities of unserviceability. Kerr's scepticism shines through in his opening remarks to a report on the use of this program: "This study has been based on input parameters which take an optimistic view of the state of training and organisation of the men, the recoverability of the weapon systems and the modification of certain limiting parts of the airfield schedules. Considerable effort will be required on the part of all associated with Blue Steel to achieve these predictions."[33] Kerr was correct.

Freefall bombers were armed in a straightforward manner – the weapon was issued and loaded. Arming with Blue Steel, however, involved the issue of the weapon from the Missile Servicing and Storage Building, the fitting of the warhead, checking compatibility with the aircraft and missile fuelling. Each step required specialised teams and ground handling equipment, at different airfield locations. The computer program focused on the "Missile Airfield Pattern": preparation of the missile after issue from the store, its loading to a prepared aircraft, the testing of the aircraft/missile combination and the loading of propellants. A "Secondary Airfield Pattern" involved the generation of partly-prepared missiles already fitted with warheads. In this pattern, the missile was moved to a dispersal and loaded directly to an aircraft. Simulations showed that the controlling factor on generation time was likely to be the rate at which aircraft became available for missile loading. The latter was assumed to be that of previous Micky Finn no-notice generation exercises. The computer simulation report concluded: "Holding aircraft and missiles at advanced states of readiness gives a valuable increase in generation capability, particularly in the early stages of

[32] Ibid.
[33] AIR 14/4356, Bomber Command, Operational Research Branch, Memorandum No. 288, "A study of Blue Steel weapon system generation using computer simulation", April 1964.

generation. If aircraft and missiles cannot be made available for this purpose, the first system generated in the powered role will not become available in much less than 10 hours."[34]

If serviceability and readiness are set aside, Blue Steel certainly looked a winner and, once launched, was virtually invulnerable, as described by Squadron Leader Robin Woolven: "Here is this eight-ton missile capable of Mach 3, with an inertial guidance system and a megaton warhead."[35] However, by the time Woolven reached his squadron, in April 1964, the switch to low level was under way, cutting Blue Steel's already meagre range by at least two-thirds, to 50 miles at best.

Norman Bonnor, a Victor Nav/Radar with 100 Squadron at Wittering (1964-66), contributed to efforts to make Blue Steel viable. He and his crew were dissatisfied with the SOP for aligning Blue Steel's inertial guidance system: "We soon realised that the SOP had been written during the trials programme in Australia and nobody had considered revising it since the system had entered operational service."[36] They found a way of saving up to 20 minutes:

> The INS could not be started up and aligned on the ground because, in a war situation, we would have only four minutes' warning to complete a scramble take-off; the SOP, as written, took about 15 minutes to start up the gyros and level the system. We were not supposed to start the SOP until in level flight at our cruising altitude. We couldn't see the point of waiting and felt we should begin activating the system during the climb.[37]

> We – that is, the Nav/Plotter and I – called up a senior scientist at RAE Farnborough, who had been involved in the design, and asked him what he thought of aligning the INS in the climb. He couldn't see a problem. So, we began using the faster procedure in the climb and were soon completing many more practice attacks than other crews. We were asked what was going on by the Squadron Commander, Wing Commander John Herrington (later, Air Vice-Marshal). He told us to continue ignoring the SOP, adding: "You must tell all 100 Squadron crews, but don't tell 139". However, with 100 Squadron outperforming 139, the Station Commander, Group Captain Lawrence, got involved. He told us to carry on, adding: "Tell 139, but don't tell Scampton!"[38]

Norman Bonnor has interesting and balanced views on Blue Steel's reliability:

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[34] Ibid.
[35] Robin Woolven, Vulcan Nav/Plotter; "Defence through deterrence: British policy during the 1960s and 1970s". Witness Seminar, Institute of Contemporary British History and Defence Studies Department, King's College, London, September 10 2014.
[36] Norman Bonnor, Victor Nav/Radar; "Blue Steel - the V-Force's stand-off bomb"; paper (undated).
[37] Ibid, "General Notes"; amongst documents/text provided: 1/11/20.
[38] Ibid.

> It has been suggested that only half the Blue Steels would have worked on the day, had that day come. It is true to say that, initially, it was not unusual to find the weapon unserviceable on going out to the aircraft. It did take several hours to mate missile to aircraft, involving the marriage of a whole series of complex butt connections. Frequently, on starting up the system, missile and aircraft would refuse to talk to each other. The mating could take four hours and it was very awkward work, as the Victor sat very low on the ground… It came as quite a surprise when we were ordered to fly with what we called "wet" rounds… that is, fully fuelled with HTP and kerosene but without – of course – a warhead. This had good results, as the reliability of the whole system improved.[39]

Testing generation: "Mick" and "Micky Finn"

During 1964, various drills were held to speed up Blue Steel generation, including "Exercise Extrude" in June and "Exercise Imperious" in July, involving Scampton and Wittering respectively on a "partial no-notice" basis. The stations were pre-warned that the exercise would be called during a specific week. Blue Steel's problems were compounded by the lengthy periods required for missile recovery after exercises. Bomber Command studied missile recovery performance at Scampton following the August 1964 "Exercise Mick" (the first full no-notice generation exercise at a Blue Steel station). Scampton generated 11 missiles, 10 of which were loaded to aircraft. It took 28 days to complete missile recovery, a shorter period than that required for recovery from "Exercise Nursemaid" that April and "Exercise Extrude" in June, "but considerably longer than the potential achievement of 10-11 days." The reasons included the wet tests required due to missile leaks.[40] The recovery of missiles at Scampton was reduced to 19 days after "Micky Finn 4" that October.[41]

Were there signs of genuine improvement in generation, regeneration and, in the case of Blue Steel, missile recovery? Both Scampton and Wittering took part in an Exercise Mick generation exercise on October 11 1965. Bomber Command Chief Research Officer R.J. Monaghan described the results as "most encouraging" and added: "Increased holding of pre-fuelled missiles and improved serviceability of aircraft undoubtedly helped in the early stages of generation, but there were delays in the generation of later systems." As for underlying reasons, he noted that

[39] Ibid.
[40] AIR 14/4368, Bomber Command, Operational Research Branch, Memorandum No. 307, "Missile recovery from Exercise Mick at RAF Scampton", December 1964.
[41] AIR 14/4369, Bomber Command, Operational Research Branch, Memorandum No. 308, "Missile recovery from Exercise Micky Finn 4 at RAF Scampton", February 1965.

Scampton's troubles involved missiles whilst Wittering's problems were with aircraft, but, in both cases, the common denominator was a shortage of spares.[42]

The October 1965 Exercise Mick was the first generation exercise involving both Blue Steel stations since the previous March. Maximum systems generation was required. Scampton had 22 aircraft; 14 were available after allowing for QRA, detachments and other commitments. Wittering had 20 aircraft and 12 available (increasing to 13 when an aircraft returned from the manufacturer six hours after the Alert). Both stations had 28 missiles and 19 available (each had five fully-fuelled and serviceable). In the case of Scampton, another four Blue Steels were unfuelled and serviceable and 10 more unfuelled and unserviceable. At Wittering, six missiles were unfuelled and serviceable and a further eight unfuelled and unserviceable. In all, the two stations generated 27 Blue Steel systems, 24 in the powered and three in the unpowered mode.[43]

Scampton generated 14 weapon systems, 11 powered and three unpowered (one was issued unpowered and two others developed leaks during HTP filling which could not be rectified). Monaghan's report reviewed results: "The generation achievement at Scampton bettered the BCAR requirements for the intermediate times of eight, 10 and 12 hours after the Alert and only just failed (by about 25 minutes) to meet the requirement for the number of systems to be ready within 16 hours of the Alert, that is, the latest time for which procedures gave a definite requirement." As for Wittering, 13 weapon systems were generated, all powered, and the generation achievement met BCAR requirements for the number of systems to be ready within eight, 10, 12 and 16 hours of the Alert, although "the generation of some of the later systems was prolonged …"[44]

Problems were identified at both stations. At Scampton, only one of the two missile gantries was serviceable (and this failed twice); filling was dogged by an unusually high number of HTP leaks. Wittering benefitted from a revised Airfield Pattern, avoiding delays in the use of missile transporters. Further benefits were anticipated from the revised Airfield Pattern and plans were underway to increase to eight the mandatory holding of pre-fuelled missiles. Lack of essential spares, however, was a

[42] AIR 14/4380, Bomber Command, Operational Research Branch, Memorandum No. 321, "Analysis of Blue Steel system generation in Exercise Mick, October 11 1965", December 1965.
[43] Ibid.
[44] Ibid.

persistent problem at both stations.[45] The real problem, however, was that Blue Steel was a liquid-fuelled weapon of great complexity, requiring lengthy preparation.

The uncomfortable contrast between freefall and Blue Steel generation persisted. A Micky Finn was called in October 1964, generating 61 MBF freefall and TBF systems – 85% (52) within 10 hours and 97% (59) within the planned 20 hours. Of the 35 systems planned to disperse, 94% (33) had been regenerated within 24 hours. As for Blue Steel, 30 weapon systems were available for the exercise – the first full generation of the Blue Steel force. The results offered a sharp contrast to the freefall figures: 47% (14) Blue Steel systems completed initial generation within 20 hours and 86% (26) within 40 hours. The results were described, in a draft minute from ACAS (Ops.), as "much slower than expected" and "less encouraging" than the freefall outcome – which showed improvement over the previous year.[46]

Micky Finn 5, initiated on July 5 1965, was another major no-notice test of the BCAR plan and the second involving generation, dispersal and regeneration of Blue Steel systems (but with only Scampton participating). The surprise Alert came at 03.00 and challenged Scampton to generate the maximum number of systems and disperse to five airfields: Burtonwood, Coningsby, Elvington, Kinloss and Lossiemouth, followed by regeneration to combat ready. The signal to disperse when ready came at 10.00. Scampton had 24 aircraft on strength; 12 were available – the others were on QRA, detached or overseas. The availability was unusually low, four less than for Micky Finn 4, in October 1964 – in part due to two aircraft attending the Calgary International Air Show and a third aircraft on a "Goose Ranger" (the latter was back at Scampton by early evening and, subsequently, was generated).[47]

As for missiles, Scampton had 28 on strength and 20 were available (three more than for Micky Finn 4). Five of the 20 were fully fuelled and serviceable, two were unfuelled and serviceable and 13 were unfuelled and unserviceable. Scampton managed to generate and disperse 13 aircraft, four each to Burtonwood and Kinloss, two each to Elvington and Lossiemouth and one to Coningsby – the most successful result to date, largely due to the highest initial aircraft serviceability achieved so far (50%). This

[45] Ibid.
[46] AIR 8/2369, "Exercise Micky Finn – October 1964", draft minute from Air Vice-Marshal D.G. Smallwood, ACAS (Ops.), November 1964, subsequently sent to CAS for a possible minute from him to the Minister (RAF).
[47] AIR 14/4378, Bomber Command, Operational Research Branch, Memorandum No. 319, "Analysis of Blue Steel system generation in Exercise Micky Finn 5", September 1965.

was not matched by regeneration performance at the dispersal airfields, with results "far below expectation". A Blue Steel system was considered capable of regeneration within three hours of landing but this was achieved by only four of the 13 systems, the remaining nine taking 3¾ –11 hours. Only five of the expected nine systems became available within 24 hours and only eight of an expected 11 systems were available within 28½ hours. The final outcome was summed up in the exercise report: "Ten powered and three unpowered systems were ultimately prepared at dispersal airfields within 43½ hours of the declaration of the Alert, but one of the unpowered systems was considered usable in the powered role in a war situation."[48]

Bomber Command's response to Blue Steel's relatively poor showing in Micky Finn 5 and the January 1966 Exercise Mick was to devise a new type of no-notice generation and dispersal exercise for Wittering and Scampton. Known as "Exercise Finnigan", it was first called on March 7 1966. This generated 24 Blue Steel systems, 20 in the powered mode. The results confirmed the powered bomb as an on-going challenge. BCAR requirements for generation were met but the later systems reflected difficulties in aircraft preparation. Twenty-three systems were dispersed and regenerated but over half took more than four hours to recover. In the case of Wittering, for example, generation of the last six systems required 25¼ to 76½ hours, with regeneration ranging from 3¾ to 22½ hours. In short, only a small proportion of Blue Steel systems were generated relatively quickly; later systems took as long as two or three days.[49] Clearly, the stand-off bomb was a weapon requiring generous political/Intelligence warning and an enemy in no particular hurry.

Missile dependability on QRA remained a concern. The maximum permitted QRA time for a fuelled missile was 30 days (extended to 40 days from August 1965). An Operational Research Branch report detailing Blue Steel standby periods at Scampton and Wittering during the April-September 1965 period looked at 44 weapon system QRA periods. There was little difference between the two bases in the average time spent by systems on standby, the overall average being about 17.7 days (similar to freefall station figures). If a missile had been in the "wet" condition before going on QRA, less than 30 days (or 40) was available to it whilst on standby.

[48] Ibid.
[49] AIR 14/4389, Bomber Command, Operational Research Branch, Memorandum No. 330, "Analysis of Blue Steel system generation in Exercise 'Finnigan'", June 1966.

There were also the unserviceabilities; there were 15 premature removals in the period and 11 missiles were on standby for less than 13 days.[50]

In July 1966, Bomber Command consolidated Blue Steel exercise performance data. The review took in the results of 16 generation exercises involving Scampton and Wittering, ending in Micky Finn 6, in May 1966. The early exercises, in 1964, required generation of a limited number of systems from a pre-arranged start-time. Subsequent exercises were no-notice and (with the exception of the first two in 1965) required generation of the maximum number of systems. Six of the 16 exercises also required dispersal. Two major factors influenced system generation performance: changes in missile fuelling and "Airfield Patterns" and, secondly, a progressive increase in missiles held in a pre-fuelled state. In October 1965 a revised Airfield Pattern was introduced, allowing missiles to be offloaded from transporters and left at the aircraft pans, awaiting readied aircraft. By March 1966, both Wittering and Scampton held eight missiles in the pre-fuelled state. "Control Aids" also led to improvements. These were tools to promote timely decision-making, to avoid bottlenecks and delays. However, there were limits to improvement. The report setting out the review findings (No. 332) summed up the situation: "There was a steady improvement in generation achievement in the first 15 to 18 months of the period, but the achievements of the last nine months have been somewhat variable. Regeneration achievement has also improved, though to a lesser extent for Wittering than for Scampton. Both stations have difficulty in regenerating systems within the guiding time of three hours laid down in the BCAR procedure."[51] The Memorandum called for "continuous pressure" to improve.

Yet, 12 months later, in July 1967, Bomber Command shied away from testing the generation, dispersal and regeneration capabilities of Blue Steel and freefall squadrons on an equal footing. During that month, Air Vice-Marshal L.M. Hodges, ACAS (Ops.), wrote a note to the PS to CAS, commenting on the results of a just-completed Micky Finn: "C-in-C Bomber Command has just telephoned me to say the exercise has been successfully completed and 66 aircraft were 'scrambled' from dispersal and main bases in under two minutes."[52]

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[50] AIR 14/4385, Bomber Command, Operational Research Branch, Memorandum No. 326, "The likely operational effectiveness of the Blue Steel QRA force: April-September, 1965"; March 1966.
[51] AIR 14/4391**,** Bomber Command, Operational Research Branch, Memorandum No. 332, "Review of Blue Steel system generation: March 1964-May 1966", July 1966.
[52] AIR 8/2369, "Bomber Command, Exercise Micky Finn", note, AVM L.M. Hodges, ACAS (Ops.), to the PS to CAS, July 13 1967.

He continued, with no trace of irony:

> The only difference between this exercise and previous ones is that, in this instance, the Blue Steel stations were given the "go-ahead" 24 hours earlier, in view of their slower force generation. This has meant that the Blue Steel force was able to disperse at about the same time as the freefall force and was better from a morale point of view.[53]

Hodges added: "I think CAS may wish to be aware of the successful conclusion of this exercise."[54]

In response to the research question, this chapter clearly identifies the central factor which leads to the thesis conclusion, that the V-Force core retaliatory threat, the destruction of Moscow and Leningrad, was maintained during the 1960s, through the adoption of Alert Condition 1 early in the decade. This posture, examined further later in this narrative, represents fully optimised UK Ground Alert. In the areas of generation/dispersal/regeneration, an analysis of ORB studies exposes the problems underlying an uncomfortable disparity between the generation/regeneration performance of freefall and Blue Steel squadrons. The immense effort made to overcome at least some of Blue Steel's shortcomings is described, together with the modest improvements achieved. In summary, this chapter clearly shows that fundamentally correct decisions were taken on crucial Alert and Readiness issues, despite the persistent reluctance of senior ministers and commanders to face up to the operational realities, by continuing to rely on over-optimistic assumptions and highly selective lines of argument.

[53] Ibid.
[54] Ibid.

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VULNERABILITIES ON THE GROUND: SURVIVING A WAR SCRAMBLE

"ATTENTION. ATTENTION. THIS IS THE BOMBER CONTROLLER FOR BOMB LIST DELTA. SCRAMBLE. AUTHENTICATION WHISKY NINE JULIET."

Squadron Leader Roy Brocklebank: "So would start the Third World War in the 1960s".

This concluding chapter on MBF vulnerabilities on the ground draws together several themes: the onerous QRA/exercise regime, security issues (including sabotage threats), measures taken to improve response times (such as SIMSTART) and recognition of the gravest threat: a low trajectory, short warning missile strike on the airfields. This was the context for Alert Condition 1, with around one-third of the main force at 24/7 Cockpit Readiness, poised for engine start. In exploring the challenge of surviving a war scramble on detection of short warning missiles, this chapter presents clear evidence that Alert Condition 1 was the sole Ground Alert posture with a potential to allow a small group of V-bombers to escape and proceed with retaliation. At the same time, the chapter also recognises several serious planning failures which, in themselves, could have increased casualties in a war scramble.

Exercising Armageddon

From 1959 onwards, the V-Force exercised regularly to test readiness for war. Early dispersal exercises began in May that year with "Mayflight 1", a pre-notified exercise testing administrative, engineering and operational facilities required by crews to maintain combat status. There was also "Exercise Kinsman", a notice drill requiring individual squadrons to fly to and operate from dispersal airfields, so familiarising crews with wartime conditions. The 1960s opened with regular no-notice exercises ("Mick", requiring generation of aircraft and weapons, and "Micky Finn", requiring generation and dispersal). Over three days in November 1963, Micky Finn 3 involved 103 V-Force aircraft; 102 were combat-ready at main bases or dispersals within 24 hours.[1] This did not involve Blue Steel; it was confined to freefall main force and TBF squadrons.

[1] White, *The King's thunderbolts*, 182.

Four years previously, in November 1959 and almost immediately upon joining XV Squadron, John Laycock – then a Victor Mk. 1 Co-Pilot – flew with his new crew from Cottesmore to St. Mawgan, Cornwall, on "Mayflight 2", a dispersal exercise. It was all very new, including the possibility of being turned out of bed for a night Alert requiring RS05 – Cockpit Readiness:

> There was always the possibility of RS02 – engine start. We would then wait for the next order or taxi. At Cottesmore we had Standard Vanguard cars and J2 vans to take us to the aircraft. The idea was always to be together as a crew. The Mess, sleeping accommodation and Operations Block were in a 100-yard triangle. We had our evening meals in the Mess and the cars were outside.[2]

Vulcan Nav/Radar Roy Brocklebank recalls how QRA alerts were broadcast in crisp terms: *"This is the Bomber Controller. For the QRA force only. Exercise EDOM. Readiness 05."* This would be repeated three times:

> You had a maximum of 10 minutes to go from RS15 to RS05. The time physically required depended, to some extent, on station layout. At RAF Cottesmore, for example, a night alert meant getting up, dressing, a car drive along a stretch of main road, then a turn down the "Lazy Runway" (closed/disused), to complete a half-mile run to the dispersal – followed by the rush to board the aircraft. RS05 required all five crew members to be inside, with the door shut. Achieving that reaction in 10 minutes was not an "automatic satisfactory". It worked on a par system – like golf. If your par time was 7½ minutes and, one night, it took longer, someone would want to know why.[3]

It is remarkable that, having invested huge sums building the V-Force, paltry funds were not found to provide reliable transport for QRA crews requiring every available second to get off the ground. Phil Leckenby did two tours at Waddington, as a Vulcan B. Mk.1A Co-Pilot, then as a Captain on 101 Squadron flying the B. Mk.2. He recalled the ancient Morris J2 vans:

> Firstly, the woefully undersized engine was notoriously reluctant to start. Even in a Summer heatwave, it would be coaxed into life only with difficulty. In wet, cold weather it was a toss-up as to whether the starter-motor or the battery would give up the unequal struggle first, leaving the frustrated crew no option but to run to the aircraft as best they could. The second trifling imperfection lay with the J2's column-mounted gear change. As the linkage became worn, first and second gears would become increasingly difficult to engage, leaving the

[2] John Laycock, Victor Co-Pilot and Captain, XV Squadron, RAF Cottesmore; Vulcan Captain and Flight Commander, 44 (Rhodesia) Squadron; interviewed: 27/3/18.
[3] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.

> driver with the option of kangarooing uncertainly forward in third or accelerating ignominiously in reverse.[4]
>
> I have an enduring memory of a particular QRA exercise which required us to board the aircraft, start up and taxi to the runway threshold … As we ran out of the QRA hut, I caught sight of 50 Squadron's van lurching towards the dispersal in a cloud of blue smoke and a series of hesitant leaps. As we drove off in pursuit, I noticed 101 Squadron's van motionless in its parking slot, its blue light flashing in anticipation and anxious faces peering out of the windows; eventually, it must have coughed into life because soon afterwards we were treated to the bizarre spectacle of their J2 accelerating away rapidly in reverse, weaving an uncertain path backwards to the waiting aircraft.[5]

Speed of response meant life or death in a war scramble. Perhaps the organisers of V-Force ground transport were of Russian heritage?

The threat from Spetsnaz

Perhaps the Russians were already here? The risk to the MBF on its airfields was not confined to manned bombers and missiles. During the 1960s there was plenty of lurid Sunday newspaper coverage of the threat from "Spetsnaz", Soviet special forces. That risk might be real enough in a close approach to war. Spetsnaz roles certainly included the destruction of NATO nuclear weapons, although, in the UK case, there would have been obvious difficulties regarding insertion (but there was also the potential risk from "sleepers").[6]

Generally, MBF station security was low key during the 1960s, with poorly protected gates, perimeters and aircraft. There was easy access from public roads adjacent to or even intruding into bases. Veterans' accounts of low levels of protection are supported by documentary evidence discussing, *inter alia*, whether one RAF Policeman with sidearm and dog could guard two nuclear-armed aircraft - given a minimum separation distance of 150 yards, and the use of ground personnel in a "Home Guard" role. Even during the Cuban Crisis, there appears to have been no major tightening of base security. Prevailing attitudes were summed up by Vulcan Navigator Robin Woolven: "…a former Thor squadron commander told me that on hearing of the Cuban Crisis escalating on the Saturday morning, he personally

[4] Phil Leckenby, Vulcan Co-Pilot and Captain, "QRA – a personal reminiscence", *655 Maintenance and Preservation Society*, Issue 29 (Spring 2013); originally published in the *44 (Rhodesia) Squadron Newsletter*.
[5] Ibid.
[6] Mark Galeotti, *Spetsnaz: Russia's special forces* (Oxford (UK)/New York: Osprey Publishing (Bloomsbury), 2015), 5, 15, 19.

authorised his RAF Police guards to load their weapons but his boss countermanded the order as 'somebody might get shot!'."[7]

The USAF had a different approach. As a 14-year old Air Cadet, this author visited Brize Norton in 1963 and saw the heavily-armed jeep patrols guarding SAC B.47s on their aprons. Bomber Command appeared to regard CND as more of a threat, followed in the 1970s by the Provisional IRA. TACEVAL, however, brought a change of heart, with recognition of the Spetsnaz threat. In the 1980s, armed guards appeared, but it was only in 1999 that the Military Provost Guard Service was established, to provide dedicated armed security at military bases.[8]

According to a paper by USAF Major Burton A. Casteel Jr. (April 1986), Spetsnaz exposure was real enough. He described it as "a significant threat to the USAF, whether at home or on foreign soil."[9] Equally, modest RAF security efforts at MBF bases during the 1960s should not be belittled, as plans for much greater protection in a crisis did exist. In 1958, all RAF Commands received orders regarding preparations for global war. Procedures included "State Black", requiring "unobtrusive measures" to safeguard operating forces, including deployment of LAA and RAF Regiment units, together with the evacuation of families from V-Force bases.[10] The need for effective ground defence was recognised, at least on paper.

At the ready

Force dispersal gave the Soviets more targets to cover but the primary survival benefit was avoidance of the take-off queue. A dispersed flight of four aircraft could take-off in one minute 45 seconds or less, assuming crews at RS05 and then RS02. With "double crews" for the RS05 portion of the force, it would have been possible, if uncomfortable, to maintain 24/7 Cockpit Readiness for these aircraft, during a period of acute tension – in effect, creating a much enlarged, dispersed QRA at the highest possible Readiness, just short of engine start. This, combined with dispersal to airfields in the north and west, direct communication with the Bomber Controller at High Wycombe via Telescramble, SIMSTART and ORPs, represented fully optimised Ground Alert readiness. Aircrew certainly appreciated the significance of timely

[7] Robin Woolven, Vulcan Nav/Plotter; email: 8/2/22.
[8] Wikipedia, 2022 "Military Provost Guard Service". Last modified January 21 2022, https://en.wikipedia.org/wiki/Military_Provost_Guard_Service
[9] Major Burton A. Casteel, USAF, "Spetsnaz: a Soviet sabotage threat", Report No. 86-0500, Air Command and Staff College, Air University, Maxwell AFB, April 1986.
[10] AIR 2/14716, letter from Air Vice-Marshal J.N.T. Stephenson, ACAS (Policy), to AOC-in-Cs of all RAF Commands, September 1958.

dispersal, but would there be time to complete the lengthy generation/dispersal/regeneration process? Vulcan Pilot Edward Jarron regards this as "a realistic assumption. I also think that the proportion of the force surviving a war scramble would have been high in those circumstances. Once dispersed, the crews didn't need 15 minutes. I think the scramble survival rate would have been good."[11] Equally, it is a fact that crews *were not fully briefed on how to maximise their chances of surviving a war scramble*, as discussed later in this narrative.

Vulcan Captain John Huggins made the essential point: "Dispersal meant aircraft could get airborne in the minimum time, without having to queue … Every field had hard points pre-prepared, with a direct line to High Wycombe. Once on the pad, the aircraft was plugged into the ground point and the Bomber Controller talked directly to the crew, who maintained radio silence."[12] Robin Woolven, a Blue Steel Vulcan Nav/Plotter with 617 Squadron, recalled that when the Alert State was raised to Cockpit Readiness (RS05) crews hurried to their aircraft: "The final external safety connections with the missile would be pulled out by the Nav/Radar, the aircraft door would be locked and the anxious crew would be listening intently to the Bomber Controller and the pips assuring us that the line was good."[13] Vulcan Captain Paddy Langdown remembers the next stage: "RS02 was ordered in a similar format to the RS05 message and involved starting all four engines using 'Rapid Start' (a developed SIMSTART system). This could spin an Olympus engine up to self-sustain speed in seconds".[14]

Scramble performance pre-QRA reflected the then dominant threat from manned bombers: 80% of aircraft airborne nine minutes after the scramble order, in favourable circumstances (assuming Cockpit Readiness), as described in Bomber Command's May 1959 Mayflight 1 exercise report:

> Estimates of performance in less favourable circumstances show that, even from a relaxed Readiness state, 80% of the force could be expected to be airborne in 14 minutes from scramble order. These reaction times are sufficient to allow unhurried decision in the event of a subsonic bomber attack on this country and are satisfactory in the face of a supersonic threat, but would be inadequate if short range ballistic missiles were used in quantity against airfields… In order to provide a manned bomber deterrent in the face of a serious ballistic missile threat, much more drastic measures than the present

[11] Edward Jarron, Vulcan Pilot; Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[12] John Huggins, Vulcan Captain; paper, "Vulcan War Flight"; amongst documents/text provided: 26/10/20.
[13] Robin Woolven, Vulcan Nav/Plotter; amongst documents/text provided: 5/11/20.
[14] Paddy Langdown, Vulcan Captain; "The Vulcan deterrent", lecture notes.

> dispersal scheme are needed, such as Airborne Alert or overseas dispersal. If an effective automatic warning system were available, a Ground Alert (engines running, on the end of the runway) would provide take-off times compatible with missile flight times, but the difficulties of implementing such a scheme over long periods of time are obvious.[15]

The report made three major recommendations: investigation of "trickle dispersal" on the initial "Alert Alpha" (generation of maximum aircraft and commencement of preparations for dispersal) – to inject more uncertainty into enemy planning and avoid a sudden drop in force availability; a study of ways to increase the deterrent value of dispersal (by making it impossible for the enemy to accurately forecast the number and location of airfields actually in use); and measures to optimise allocation of targets and weapons to crews.[16]

This report was produced when Soviet missile strength was modest. However, if dispersal airfields were used only during dispersal exercises, even a modest missile force could hope to destroy the MBF by targeting main bases alone: "It is very important, therefore, that use of the dispersal airfields should be unpredictable and, if possible, virtually continuous, so that at any time an enemy planning an offensive will find that inclusion of the dispersal airfields in his attack plan demands the employment of more missiles than he has available." That said, the report's authors appreciated that this would be short-lived: "The number of proposed dispersal airfields in this country is limited and the enemy capability increases with time. It may be important, therefore, within the effective life of the MBF, to introduce alternative methods of decreasing its vulnerability to missile attack."[17] Recognition of the essential problem was not accompanied by a solution; the MBF would depend on a potentially very short BMEWS warning and favourable circumstances for launch (after dispersal, regeneration and a proportion of crews at 05 advanced readiness).

The July 1960 "Mayflight 3" exercise took place at a time when the missile threat was receiving more attention. New measures were being introduced, such as SIMSTART and Telescramble, to get the bombers off the ground before Soviet weapons detonated. The results were set out in an ORB report which looked forward to widespread provision of ORPs. Mayflight 3 also explored trickle dispersal. Overall,

[15] AIR 14/4289, Bomber Command, Operational Research Branch, Memorandum No. 201, "Exercise Mayflight, May 4-7 1959."
[16] Ibid.
[17] Ibid.

however, Mayflight 3 suggested that any major improvement in response times would be an uphill struggle.[18]

This Mayflight involved 82 aircraft (80% of strength). “For those aircraft trickle dispersing after Alert Alpha, 50% were dispersed and ready within 10 hours of Alpha and 90% within 24 hours. For those aircraft dispersing in the normal way at Bravo, 50% were dispersed and ready within 4½ hours and 90% within 10 hours of Bravo.” There was no marked improvement in reaction times on previous Mayflight exercises. On scramble times – from Cockpit Readiness – 50% of the force reached take-off within 5½ minutes and 90% within 7½ minutes of the scramble order. One conclusion from Mayflight 3 was that reaction times could increase to up to 20 minutes in “difficult or unexpected circumstances” – such as scrambling from “Blue” (40 minutes’ Readiness) or land-line failure. The report added that further marked improvement in scramble times from Cockpit Readiness were unlikely until simultaneous engine start and ORPs were employed. The few aircraft with SIMSTART saved up to one minute 40 seconds (up to two minutes in trials). Telescramble-equipped aircraft saved about 30 seconds on time to engine start. The conclusion was downbeat; a comparison with results from earlier exercises indicated “small improvements” in generation rates and, to a lesser extent, in scramble times, but this probably reflected greater familiarity with exercise requirements than improved operational capability.”[19]

Introducing SIMSTART

Valiant Captain Tony Cottingham said it took about four minutes to start engines one by one – starting with less than a minute between engines ran the risk of blowing the main starter fuse, meaning a long delay whilst it was changed.[20]

Michael Alcock (later, Air Chief Marshal Sir Michael) was instrumental in SIMSTART’s development. As a young man he joined the Bomber Command Development Unit (BCDU) in 1959 as a National Service Technical Officer. During that Autumn Squadron Leader Dixon telephoned, on behalf of the Command Electrical Engineer:

> The AOC-in-C Bomber Command, “Bing” Cross, had recently returned from the USA, where the USAF had demonstrated simultaneous starting of all engines of, I think, a B.47 bomber. The AOC-in-C wanted to know why “his” V-bombers could not do the same trick… Dixon fired that question to BCDU’s

[18] AIR 14/4302, Bomber Command, Operational Research Branch, Memorandum No. 219, “Analysis of Exercise Mayflight 3, July 1960”, October 1960.
[19] Ibid.
[20] Tony Cottingham, Valiant Captain; interviewed: 8/2/18.

> technical officers. After an intense morning's session, poring over wiring diagrams of the Valiant together with our Crew Chiefs and SNCO electricians, we called back to say we thought it would be relatively simple to do.[21]

The team acquired a bomb trolley and mounted four engine starter panels and lots of batteries, wired directly to the starter motors of each engine. The engines were started externally by the Crew Chief, who hit all four starter buttons in turn (fully simultaneous operation caused failure due to the extreme current demand). Sir Michael recalled the AOC-in-C's reaction on witnessing a demonstration, on December 23 1959, as "a joy to behold… He turned to Squadron Leader Dixon and ordered the whole V-Force, Valiants, Vulcans and Victors – the lot – to be modified with SIMSTART as soon as possible."[22] Sir Michael regards SIMSTART as providing the basis for QRA.

A CDS memorandum of July 1961 described SIMSTART as essential and that "the modifications will reduce take-off time from 140 seconds to about 60 seconds and contribute significantly to the credibility of the deterrent against pre-emptive attack by enemy land-based ballistic missiles."[23] (The use of the phrase "land-based" is, perhaps, noteworthy). SIMSTART's total cost across the V-Force was £6.75 million: £4 million for engine-starting, including R&D, and £2.75 million for other equipment and services, including "snatch" disconnections. Initial costs of Mk. 1 SIMSTART were met from existing resources. On July 19 1961 the DCAS, Air Marshal R.B. Lees, warned the penny-pinchers: "… unless we are prepared to accept an increase of reaction time of at least one minute, no economy is possible."[24] The spend was approved by the Minister of Defence.

How much warning?

The "four-minute warning" was a common expression, but the reality was rather more complex. In 1961, Bomber Command took a close look at what could be expected from BMEWS, Fylingdales, when it became operational. An ORB study considered attacks by missiles of 650, 1,000 and 1,500 miles range, fired to maximum range in optimum trajectories and, secondly, in low trajectories with 15 deg. re-entry. The key findings included:

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[21] Air Chief Marshal Sir Michael Alcock, GCB, KBE, DSc, FREng, "V-Force development – simultaneous engine starting", article based on a paper to the RAF Historical Society, proceedings for October 22 2013.
[22] Ibid.
[23] DEFE 25/86, "V-bomber readiness", memorandum by the Chief of the Defence Staff (DRP/M(61)8, Item 4), July 3 1961.
[24] AIR 8/2238, "V-bombers – engine-starting systems", minute, Air Marshal R.B. Lees, DCAS, July 19 1961.

- A low trajectory considerably reduces missile flight time and decreases proportionally the warning time.
- Average time between a missile first entering radar coverage and being detected is 10 seconds (average time between two successive “looks”).
- The most westerly bases had an increase in minimum warning time of one to one and a half minutes.[25]

A 1,500 miles range missile fired to maximum range “should be detected at least 10.5 minutes before impact for targets in Eastern England, this time increasing to 11.3 minutes for targets in the extreme west of the UK.” If the same missile could be fired on a low trajectory over 1,000 miles range, warning time would be reduced to between 3.5 minutes and 5.5 minutes. Launch sites for such firings could be within the borders of the Soviet Union; the use of missiles over a 650 miles trajectory would require launch sites in satellite countries. Given deployment near the East German border, missiles could hit the UK’s most westerly targets. If missiles were fired on low trajectory over 650 miles, warning time would vary between 3.5 minutes for East Anglia to five minutes for Northern Ireland.[26]

The critical factor determining warning time was the capability to fire on low trajectories. If low trajectories could not be used and missiles were fired on minimum energy trajectories, there would be significant increases in warning times:

> … Taking a target in the Midlands, the warning time would be 7.5 minutes for a 650 miles trajectory, 9.2 minutes for a 1,000 miles trajectory and 10.8 minutes for a 1,500 miles trajectory. There would be an advantage, therefore, from the Russian point of view, in forward deployment of missiles in this case. The smallest warning times from missiles fired from Russia are approximately 4.2 minutes at Fylingdales Moor when a 1,000 miles missile is fired on a low trajectory over 650 miles range. Significant improvement in warning times can only be achieved by using dispersals in the most westerly areas in the UK.[27]

How vulnerable?

Freefall Vulcan Captain John Huggins described the getaway in a simulated war scramble:

[25] AIR 14/4305, Bomber Command, Operational Research Branch, Memorandum No. 222, “Calculations of the minimum warning times obtainable from the BMEWS at Fylingdales Moor, of ballistic missile attack on the UK”, April 1961.
[26] Ibid.
[27] Ibid.

> The first aircraft moves out and starts its take-off run. Whilst she is rolling, the next aircraft moves out and starts rolling 15 seconds after the first one releases its brakes. The next one and the fourth one do the same. The total elapsed time is one minute 40 seconds, with the aircraft rolling down the runway two at a time. From brakes off to rotate is 30 seconds in peacetime and slightly less in war, when take-off power on the 301s would be selected. This was not used in peacetime and it increased power to 21,000 lbs static thrust each, instead of the normal peacetime 19,000 lbs cruise setting. [28]

Crews on dispersal airfields, in the ultimate national emergency, would be expecting the first wave of missiles: "The aircraft would be blacked out, with anti-flash screens and blinds down."[29] One or both Pilots would be wearing eye patch protection, to save one eye from flash. This was described by Vulcan Nav/Radar Roy Brocklebank as a "sensible precaution" against total blindness.[30]

The chances of surviving a missile strike on the airfields were slim under any scenario other than "simultaneous impact" attack. Other attack modes ("simultaneous launch" and an attack on the UK in isolation) left Britain with around 3.5 to 4.5 minutes' warning. Only crews at RS05, ready for immediate engine start and positioned first for take-off had any real chance of escape. John Huggins had no illusions:

> Naturally, we thought about that "four-minute warning". It would take, at the very best, at least 15 seconds from early warning to the order for scramble. My fastest ever four-aircraft scramble was one minute 46 seconds. Could we get far enough away to escape the blast from weapons falling on the airfield? Some crews fancied their chances by climbing, but that meant going westwards (taking off into the prevailing wind), then circling to head east. Almost certainly, they would be passing through the nuclear clouds which would have been all that was left of Scampton, Coningsby and the rest. I had another idea. We would go ultra-low and seek shelter from the "Lincolnshire Edge", a drop of about 200 ft. We would go down to 50 ft, hoping the blast wave would travel over the top of us. I didn't really think much of our chances.[31]

In fact, the best survival tactic during "flyaway" was to climb to at least 5,000 ft, even at the sacrifice of some escape distance, to avoid magnified shockwaves near the ground. A March 1962 Bomber Command study of MBF vulnerability to missile attack attempted to answer the fundamental question: could the bombers escape, making a successful war scramble? This report estimated the weight of attack required to neutralise the MBF (under various circumstances) and considered the effects of

[28] John Huggins, Vulcan Captain; amongst documents/text provided: 26/10/20.
[29] Ibid.
[30] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; note: October 2018.
[31] John Huggins, Vulcan Captain; amongst documents/text provided: 26/10/20.

warning time delays in scrambling aircraft, together with survival issues relating to tactics immediately after take-off. Its conclusions were disturbing. This study assumed dispersal over 24 airfields with overlapping flyaway patterns and examined the issues in two parts. The first considered weight of attack required to neutralise the MBF whilst still on the ground, including estimates of aircraft vulnerability, weapon yield, accuracy and reliability. The second part included estimates of the probability of aircraft survival, in relation to warning times, given assumptions concerning missile trajectory and aircraft reaction times.[32]

Part 1 considered an attack on aircraft parked on airfields, with assumptions taking account of a range of aiming error, weapon yields of 1, 3 and 10MT and blast overpressures of 3 psi and 5 psi. This allowed the relationship between yield, overpressure and damage radius to be presented. It was assumed that the V-Force was dispersed, with three aircraft parked randomly on each airfield. It was recognised that aircraft would be clustered on ORPs, but that was found to make practically no difference to results. On the important matter of airfield separation, the report commented: "Although most of the airfields considered are far enough apart to ensure that each airfield will be attacked independently, there are some which are close enough for one weapon to neutralise aircraft on two or more airfields." Each missile striking an airfield (assuming IMT yield) was judged "practically certain" to neutralise parked aircraft. Assuming a 3.6 miles damage radius and 1.5 miles probable circular error (CEP):

> …there is a 98% chance of neutralising the aircraft … With weapons of higher damage radius or lower CEP, aircraft on more than one airfield may, in some cases, be neutralised by one weapon… The most likely values of the variables involved are a CEP of one mile, an overpressure level of 5 psi and missile reliability ¾. With these values, the number of missiles needed is 35 missiles with 1MT warheads, 35 missiles with 3MT warheads or 32 missiles with 10MT warheads. Because of the very small decrease in numbers with an increase in yield, it seems unlikely that warheads of greater yield than 1MT would be used …[33]

In considering the effects of missile attack on aircraft after take-off, strategic warning of a likely attack was assumed, allowing dispersal and regeneration to Readiness, a state of Cockpit Readiness when the missiles are detected and take-off of a flight of three Vulcan 2s at 30-second intervals. The ability to get well away before the missiles

[32] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No. 241, "The vulnerability of the MBF to ballistic missile attack", March 1962.
[33] Ibid.

burst was limited by the time lag between BMEWS missile detection and the first aircraft starting to move down the runway. The time lag consists of delays in transmitting warning to the aircraft, the time taken to start engines and the time to taxi to the runway (minimum: 90 seconds). It was assumed the bombers would achieve a 30-second interval take-off (i.e. with the second aircraft starting to roll on the runway as the first aircraft lifts off and that the aircraft then climb at the maximum rate and start a turn, in either direction, at constant bank, 30 seconds after lift-off, continue to turn and then level out. Turns of 20 deg. and 40 deg. bank were considered.[34] Vulcan Nav/Radar Roy Brocklebank regards a 20 deg. bank turn after launch as "most unlikely, with 40-45 more likely, to get tail on to the target – your base." He also describes a 30-second stream as improbable: "It would more likely be 10-15 seconds, so the fourth aircraft would be airborne no more than 60 seconds of No. 1 brakes off (Mk. 2s, that is)."[35]

Warning time depended on missile trajectory. An IRBM with 1,000 miles maximum range, launched low trajectory from 650 miles, would provide around four minutes' warning (but nine minutes if launched from maximum range). Airfields in the north and west would receive longer warning. The study allowed for the loss of 1.5 minutes (30 seconds delay in transmitting the BMEWS warning and one minute for delays on airfields until the first aircraft is rolling). There were then assumptions concerning damage radius and aiming error. The damage radius depends on yield and levels of overpressure, gust, thermal and nuclear radiation which the aircraft can withstand. The assumed yield was 3MT and a value of 1.5 psi overpressure assumed to neutralise aircraft: "The exact values of overpressure and gust which are required to neutralise a Vulcan are somewhat doubtful, but the values of 1.5 psi and 100ft/second used are the best available estimates, assuming random orientation of the aircraft relative to the direction of the missile burst." Given these levels of overpressure and gust, levels of thermal and nuclear radiation were not regarded as critical.[36]

"With these damage criteria, the damage radius of a 3MT warhead is six miles for aircraft flying at altitudes between 6,000 ft and 40,000 ft." Aircraft attempting to escape by staying low, rather than climbing to at least 6,000 ft, would have been destroyed: "Below 6,000 ft the damage radius rapidly increases to about 12 miles …

[34] Ibid.
[35] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 20/4/19.
[36] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No. 241, "The vulnerability of the MBF to ballistic missile attack", March 1962.

(the overpressure is doubled by reflection at the Earth's surface)."[37] Roy Brocklebank confirmed this conclusion: "This is the Mach Stem effect. The airburst weapon has its shock front increased by reflection from the ground."[38]

The Bomber Command report set out in more detail the consequences of staying low:

> Since the aircraft are assumed to climb at maximum rate, an altitude of 6,000 ft will be rapidly attained (about 1.6 minutes after take-off) and the Mach Stem effect will not be important. If, however, aircraft were to fly for some time at low altitude, the damage radius of the warhead would be doubled and, hence, the area of damage would be quadrupled. Thus, the proportion of the force neutralised will be increased if aircraft fly for any length of time at altitudes below 6,000 ft; in some circumstances, the damage may be increased fourfold.[39]

Surprisingly, given this factor's great significance, V-bomber captains were not briefed on this subject and, instead, were allowed discretion on whether to continue climbing or stay low – with the latter option guaranteeing that they would *not* outrun the blast. This was a major failure by Bomber Command's leadership, given the explicit conclusions of the ORB study of vulnerability to missile attack. Given the gross nature of this oversight and/or negligence, it is hardly surprising that no later documentary evidence was found to explain an omission which further reduced the survival chances of those few bombers which might escape a short warning missile strike. The oral evidence, however, is compelling: no aircrew veteran contributing to this thesis recalled a specific warning that climbing immediately after a war scramble was *absolutely essential* for survival.

Surviving "flyaway"

Elements contributing to scramble outcome included enemy uncertainty over direction after take-off – whether aircraft would fly straight ahead or turn left or right, together with considerable variation between airfields of the time lag between BMEWS missile detection and aircraft take-off (so that bombers will not necessarily reach maximum potential distance from their airfields). "Thus, when missiles explode, an aircraft must be assumed to be anywhere within a certain region around its airfield, determined by the maximum performance of the aircraft and the effective warning time." The area around the given airfield was considered as three regions – an inner region in which three aircraft may be found, a strip around this where only the first

[37] Ibid.
[38] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 5/4/20.
[39] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No. 241, "The vulnerability of the MBF to ballistic missile attack", March 1962.

two may be found, and another strip around this where only the first may be found. “Since the average number of aircraft per unit area is greatest in the central region, this will receive missile cover before the outer regions.” If there is any delay in transmitting the BMEWS warning to aircraft, the aircraft are more likely to be in the central region, where there will be a higher density of missile bursts.[40]

Missiles (1,000 miles maximum range) from 650 miles away offered a warning from 3.6 minutes (at Honington) to 4.6 minutes (St. Mawgan and Lossiemouth):

> Assuming cockpit readiness and a loss of 1.5 minutes from the warning time to wheels rolling at the end of the runway, the first aircraft to take-off can fly eight and 17 miles respectively from its airfield. With these short warning times, the 24 airfields are practically independent. There is a little interaction between three pairs of airfields, but this is sufficiently small to be neglected, so that the results of damage to aircraft from single airfields may be applied directly. [41]

The study assumed that, with one missile per airfield, the enemy would prioritise airfields in the south-east, with the shorter warning times, since these have a higher average density of aircraft:

> With 24-48 missiles, one missile is allocated to each airfield and a second missile allocated to airfields in the north and west with the longer warning times, since more aircraft would escape the first missile on these airfields. Any further missiles are allocated to the few airfields where there is a chance that some aircraft may escape two missile bursts.[42]

If missiles are fired from 1,000 miles, the 8.8-9.5 minute warning would allow aircraft to be some 60 miles from their airfields when warheads burst:

> In this case, there will be considerable interference between airfields, except St. Mawgan and Lossiemouth, if aircraft from each airfield may fly away in any direction from their airfields. With aircraft equally likely to fly away in any direction, there will be considerable variation in the expected density of aircraft at different points; there will be regions in which aircraft from as many as 11 different airfields may be found. This is clearly disadvantageous to aircraft, since unless enough missiles are available to cover nearly all the area which may contain aircraft, an unnecessarily high damage level may be achieved by allocating missiles to regions of highest traffic density. The best distribution of aircraft would be one where the mean density of aircraft is constant.[43]

[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] Ibid.

This ideal could not be achieved but density could be evened out by confining aircraft to sectors ("cones") centred at each airfield … "the sectors being chosen so that they are roughly the same size and overlap by only a small amount, but cover nearly all the areas which aircraft can reach."[44] Yet, according to Nav/Radar Roy Brocklebank, crews had no awareness of this: "No plans to avoid bunching were practised or set out, to my knowledge. Simply put, you got airborne and headed north east."[45] This is another example of oversight and/or negligence in a critical area for war scramble survival, once again ignoring key findings of ORB's report on MBF vulnerability to missile strike. As in the case of Roy Brocklebank, no aircrew veteran contributing to this thesis had heard of "flyaway cones".

The findings of the ORB were sobering, given its foundation in favourable circumstances (the key one being the improbable assumption that the *entire* dispersed MBF would be at RS05, rather than the 24/7 Cockpit Readiness maximum of 30%). The memorandum continued by stating the obvious:

> … the percentage of aircraft that escape increases as the warning time increases, and decreases as the number of missiles increases. For warning times less than 3½ minutes, one missile will neutralise practically all aircraft from one airfield. With a four-minute warning time, one missile will do considerable damage, allowing only some 25% of aircraft to escape. The situations for longer warning times, in the eight to nine minute range, are quite different. In this case, even with as many as 10 missiles round an airfield, some 75% of the aircraft may be expected to escape.[46]

A much longer warning – commonly assumed due to a Soviet staggered launch seeking simultaneous UK/USA impact – formed the basis of RS15, despite the lack of advantage to the Soviets. This may explain the remarkably high war scramble survival estimates quoted elsewhere.

The Bomber Command report addressed many critical factors influencing survival. For example, the difference bank angle made in shorter warning times "may be quite considerable … with a 4½ minute warning time and two missiles round an airfield, 12% of aircraft will escape with a 20 deg. bank turn, while 30% will escape with a 30 deg. bank turn." Any delay in giving the take-off order would be costly: "If, for example,

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[44] Ibid.
[45] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 18/3/21.
[46] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No.241, "The vulnerability of the MBF to ballistic missile attack," March 1962.

the warning time is 4½ minutes and one missile bursts over an airfield, the percentage of aircraft that escape will be cut from 55% to practically zero by a one-minute delay in take-off. Although the effect of delays becomes relatively smaller as the warning time increases, it is still not negligible."[47]

As to the threat from low trajectory missiles from 650 miles, giving only 3½ to 4½ minutes warning, the report warned: "… considerable damage can be done to the force with only a small number of missile bursts round each airfield… With 24 missile bursts, one over each airfield, some 28% of the force can be expected to escape, while with 48 missile bursts, two round each airfield, less than 10% of the force can escape. Sixty missile bursts will allow about 5% of the force to escape." This assumed the aircraft take off in either direction: "If this is limited to one direction only, fewer missiles would be needed, since aircraft would be restricted to a smaller area." In these circumstances, one missile over each airfield "will allow less than 12% of the force to escape and two missiles round each airfield will neutralise the whole force."[48] It is easy to see why planning and RS15 were based on the UK/US simultaneous burst scenario. Without a US duration warning, the UK V-Force was very close to a sitting duck, eased only marginally by the Alert Condition 1 posture – continuous RS05 for some aircraft, by crew rotation.

These numbers were based on successfully launched missiles. Assuming ¾ reliability and allowing for failures, it was calculated that 51% of aircraft would survive a 20 missile strike on airfields, given 3½ to 4½ minutes total warning, take-off in either direction, a 40 deg. bank turn and 1.5 minutes time lost. The percentage of survivors would fall to 31% (30 missiles), 22% (40 missiles) and 12% (60 missiles). Longer warning time (missiles from 1,000 miles) and aircraft flying away in designated sectors would increase the numbers escaping: "With an attack of 100 missiles, 70% of the force is expected to escape, while with 250 missiles, 32% of the force would escape. At least 400 missiles are needed to ensure that only 10% of the force escapes, whilst 570 missiles are needed to ensure complete neutralisation of the force." The effects of 60 seconds' delay were explored: "Although this effect is relatively smaller for long warning times, it is still appreciable. The proportion that escape is decreased by 7% of the force with an attack by 100 missiles and by 13% of the force with 250 missiles."[49]

[47] Ibid.
[48] Ibid.
[49] Ibid.

A weapon fired from 1,000 miles away providing a nine-minute warning (simultaneous launch BUT normal, rather than low, trajectory) would allow 98% of aircraft (independent airfields) to survive, assuming 05 (Cockpit Readiness), 1.5 minutes to first aircraft rolling and zero delay. A one-minute delay would reduce survival by only 1%, to 97% (with respective figures for two weapons per airfield being 97% and 95%).[50]

In the case of a 1,000 miles range weapon per independent airfield, launched 650 miles/low trajectory, the report stated that 26% of aircraft might survive, but this could be reduced to zero by a one-minute delay. In a two weapons per airfield case, 10% might survive, assuming no delay (zero with a one-minute delay). Warning times of 20/16 (normal/low trajectory simultaneous burst, UK/US) and nine minutes (normal trajectory/simultaneous launch):

> …are most typical of those which might be expected over the next few years. It can be seen that if the state of Readiness is matched against the current threat, one minute's delay in transmitting the BMEWS warning to the crews may be very expensive in lost weapon systems if two to four missiles arrive at their target. It appears therefore that BMEWS warning should be transmitted direct to the crews who then start engines, taxi and take-off …When the warning time falls to that corresponding to missiles fired on a low trajectory over 650 miles range, the escape chance becomes small…[51]

It is in this situation (surely the most likely) that Airborne Alert appears the only answer. Waddington Wing Targeting Officer Roy Brocklebank summed up the position on the squadrons, confirming lack of disclosure: "Crews were not briefed on this document."[52]

This study was based on simultaneous arrival of missiles, whereas, in reality, arrival would be spread over "at least two minutes". It added that the results are somewhat pessimistic "but, nevertheless, do provide a reliable guide to the changes of survival chance with time, and represent the worst case of simultaneous detonation of all weapons about each airfield."[53] To summarise, the report concluded that the chance of escape increased if aircraft can climb out in any direction, turn with up to 40 deg. of bank after take off, climb rapidly to over 6,000 ft and use flyaway patterns producing an even distribution of aircraft in the air.

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[50] Ibid.
[51] Ibid.
[52] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 20/3/19.
[53] AIR 14/4311, Bomber Command, Operational Research Branch, Memorandum No. 241, "The vulnerability of the MBF to ballistic missile attack", March 1962.

Frontline stress

Air Commodore Edward Jarron, a former Vulcan Pilot, points to the cardinal function of the deterrent:

> The most important fact about it is that it is there to deter, NOT to war-fight … When Chief of Special Weapons at SHAPE I found it necessary, occasionally, to remind the Generals that this is the case. I pushed the point at every opportunity. All bets are off when the first weapon flies. There was a lot of misguided planning in the 1960s to give nuclear weapons a battlefield role – nuclear-armed artillery and the like. Thankfully, we moved away from such plans.[54]

Bomber crews, for the most part, were confident the deterrent would deter. Yet, the special character of life on the 1960s nuclear frontline penetrated all but the thickest skins. QRA governed life from 1962 until the Polaris handover in mid-1969. QRA duty crews constantly moved up and down the Alert States and all this came at a price. They lived in a small "wartime" community, in a country at peace (although fearful that peace could end, at any time, in a four-minute warning).

Many V-Force veterans talk about QRA stress. Vulcan Captain John Huggins recalls the day when correct procedures for stand-down, after a real Alert, were ignored:

> We were ordered to go from 05 to 15 but the stand-down code wasn't given. The Waddington QRA aircraft refused to comply and crews remained at Cockpit Readiness. It was actually a false alarm. I saw the Station Commander arrive and approach the secure area. He was accompanied by the Armaments Officer, who was holding the weapon key. I told the armed guard beside our aircraft to warn them not to enter the area. I also told him to shoot them if they got within 50 ft of the aircraft. The procedures were clear: no stand-down without the correct code – which, eventually, was given. We loaded live nukes for QRA and we had the target information with us. As far as we were concerned, we could be going to war.[55]

Roy Brocklebank confirms that security arrangements in the 1960s offered scope for improvement:

> At Cottesmore we had the occasional intruder. The gates were never closed. On one occasion, a driver got confused, drove through the main gate, continued straight ahead, turned left, headed down a very wide road, turned right onto an even wider road and ended up next to three nuclear-armed aircraft. Eventually,

[54] Edward Jarron, Vulcan Pilot; Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[55] John Huggins, Vulcan Captain; amongst documents/text provided: 26/10/20.

> two-man control was extended to cover the Police guard. Extra RAF Police had to be recruited; gradually, security tightened.[56]

QRA-related stress overlaid the demands of operational flying. Many V-Force aircrew experienced incidents threatening complete disaster. Nav/Radar Jim Walker was a member of Vulcan Captain Mike D'Arcy's crew. They had a close call when all four engines were lost just after take-off: "It was a total electrical failure. The back-up was batteries – for a maximum of two minutes! D'Arcy told us to prepare to abandon. I got out of my seat and went down to the hatch. Luckily, the AEO got the bus-bars back on line and the engines re-started. We were at 200-300 ft when this happened." Walker left 44 Squadron in September 1968. He was posted to 35 Squadron, Cottesmore, as Radar Leader: "Overall, morale on this squadron was good, but there had been an accident. The Co-Pilot of the crew I joined, together with his wife, had witnessed it. He then decided he no longer wanted to fly. He was labelled LMF ('Lack of Moral Fibre') and posted out immediately. He was just a young bloke and his wife was terrified; living next door to them was the AEO who'd been killed in that accident."[57]

It might seem surprising that the harsh wartime LMF regime lingered into the late 1960s. The RAF's LMF "culture", however, was deeply ingrained. The emphasis on punishment eventually receded, giving way to "Combat Stress" and "Post-Traumatic Stress Syndrome".[58] Nevertheless, as the 1960s began, Air Council-endorsed policy for "Disposal of aircrew who forfeit the confidence of their Commanding Officers" still called for their removal at the earliest opportunity, with a posting to the "No. 1 Personnel Holding Unit". Officers not exposed to exceptional stress could be called on to resign. Logbooks were impounded, to prevent them obtaining commercial licences.[59]

Lack of ejection seats for rear crew contributed to stress. There were difficult debates, behind the scenes, over the possibilities of retrofit. Air Vice-Marshal Nigel Baldwin (1999) gave his view:

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[56] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.
[57] Jim Walker, Vulcan Nav/Radar, 44 (Rhodesia) Squadron, RAF Waddington; 35 Squadron, RAF Cottesmore/RAF Akrotiri; interviewed: 26/3/19.
[58] Edgar Jones, Professor of the History of Medicine and Psychiatry, King's College, London, "LMF: the use of psychiatric stigma in the Royal Air Force during the Second World War", *The Journal of Military History*, 70 (April 2006): 439-458.
[59] AIR 19/632, "Disposal of aircrew who forfeit the confidence of their Commanding Officers", Annex to Air Council letter A. 301810/58/S.10 (d), November 6 1959.

> I came to the conclusion long ago that it should have been done because all those Pilots who sat in the front had big responsibilities and, I suppose, influencing my thought is that I have stood in a lot of cemeteries. I buried my first Vulcan crew on my first wedding anniversary, with a young wife by my side, and we went on to do that several times in our careers… there's no doubt that I wouldn't have been there, in that old cemetery in Coningsby churchyard in 1964 that day, if there had been five ejection seats in that aeroplane … it was disgraceful that it wasn't done.[60]

Many accidents involved loss of life. Victor Captain Jeremy Mudford survived an engine fire costing three lives:

> This was a Victor B.1 and its Sapphire engines were not always reliable. In this case, the No. 2 engine drive shaft failed, at the alternator end, leaving a few inches of shaft flailing around in the engine bay, destroying wiring and fuel lines. As fuel contacted hot surfaces, there was a bang and a fire warning light came up. I activated the fire extinguisher and the engine shut down, but the engine was still turning … and still doing damage. I heard another bang and the adjacent engine caught fire. I ordered the crew to bale out. They all succeeded in leaving by the port side door – but this was on the same side as the fire. Sadly, two of the three were killed by flying fragments from the crippled engines. The third, my AEO, survived and landed safely. I told my Co-Pilot to go at about 1,500 ft above the ground. He pulled the blind but his ejection seat failed to fire. I told him to leave by the side door but, sadly, we were very low… There was no point in staying. I could see the leaves on the trees; I ejected successfully at approximately 700 ft and 305 kts.[61]

Later, a Board of Enquiry concluded that the cause was mechanical failure; no blame attached to the Captain.

Cases of conscience concerning nuclear weapons were rare and, therefore, added little to stress, as confirmed by Cottesmore Co-Pilot David Dinmore:

> I was not aware, at that time, of anyone with reservations about the nuclear role. However, I recall a Navigator who left the Air Force when in his mid-thirties, to become a Church of England Minister. Later on, I talked to him and he described his calling. That conversation led me to believe that he had some regrets about his past role, but that wasn't apparent at the time.[62]

Vulcan Captain Philip Goodall (2015) recorded another case: "A while ago I met someone who said that a friend of his had been a Vulcan Captain and had decided

[60] Morning discussion period, RAF Historical Society meeting, *Journal 20* (1999): 42-54.
[61] Jeremy Mudford, Victor Captain; interviewed: 8/2/18.
[62] David Dinmore, Vulcan Co-Pilot, 35 Squadron, RAF Cottesmore (1967-70); Captain, 44 (Rhodesia) Squadron, RAF Waddington; interviewed: 1/5/19.

that he could not accept the responsibility of dropping a nuclear weapon … (he) was 'retired' from the RAF in days."[63]

Very rarely there was a knot-in-the-stomach feeling that the ultimate nightmare might come true. Vulcan Nav/Radar John Weller, IX Squadron, had such a moment – on a Tuesday evening in April 1965:

> When the siren went I was with the Scouts, in my role as Assistant Scoutmaster. I was still in my Scout uniform when I arrived at Operations. I was told to get my kit on. Was this a Mick or Micky Finn? No – it was the real thing! "Here's your target!" BMEWS had picked up incoming missiles. A USAF Major on site had been briefed on "12 parameters of retaliation". Apparently, on this occasion, 11 parameters were met. The projected target was the sole parameter not met. In fact, a satellite had broken up and the pieces had registered individually. As the fragments were in Earth orbit, rather than a ballistic trajectory, the BMEWS couldn't find the predicted targets.[64]

Many V-Force aircrew completed two or more V-bomber tours; they lived for six years or more with the onerous 1960s QRA regime. The general rule was no alcohol for eight hours before flying and, theoretically at least, given the ever-present possibility of call-out, only very moderate consumption unless stood down. There were no concessions regarding the hardships and stress of long-term V-Force duty, as experienced by both aircrew and groundcrew. Married aircrew were not entitled to a marriage allowance until reaching the age of 25. Those wishing to marry had to seek permission. Divorce could mean loss of commission and dismissal from the service. Some aircrew had to choose between divorce and being told to resign. There were social barriers in place. In general, officers were expected to avoid fraternising with NCOs and Other Ranks. There was also the constant pressure on aircrew to perform to the highest standards, within an aggressively competitive environment. Some blossomed; others had a very different experience.

V-Force morale is a complex issue. Naturally, it varied according to the individual and his circumstances. The oral evidence gives a vivid impression of forces acting on morale in the 1960s V-Force. Co-Pilots, for example, often had a tough time; some were held back by difficult Captains or squadrons with a reputation for slow advancement. Many aircrew, posted to the V-Force against their wishes, failed to warm to the role but did two or even three tours. Nuclear weapons had little influence on morale, unlike the prospect of years enduring Eastern England's bleak winters.

[63] Goodall, *My target was Leningrad*, 133.
[64] John Weller, Vulcan Nav/Radar, IX Squadron; interviewed: 1/8/18.

QRA, exercises and other commitments put relationships under strain, aggravated by awareness that separation and divorce had severe and, possibly, career-ending consequences. Flying hours were under strict control and the professional environment was fiercely competitive. It could also be very unfair: hard-won Select Star/Command status, for example, was often lost through the posting of one of the team, rather than any misdemeanour or failing. There were also occasions when morale really suffered, particularly following accidents involving the loss of rear crew due to the lack of ejection seats. There was also a negative dynamic: the conflict between constant readiness for war and a deep conviction that deterrence would hold and that a war sortie would never be flown. This could foster apathy and a lack of willingness to challenge inadequacies such as poor accommodation, blocked access to the ORP and unreliable transport to the aircraft. That said, many aircrew enjoyed their V-Force tours, relished the competition and high expectations and took pride in climbing Bomber Command's ladder of excellence. They achieved well-deserved recognition amongst their peers and demonstrated that skill, nerve and extreme combat tactics could overcome many inadequacies.

At the same time, stress did not respect rank and undermined some in senior positions. Air Vice-Marshal Nigel Baldwin flew in the 1960s V-Force:

> I recall that, when I was a Flight Lieutenant Captain of 35 Squadron at Cottesmore, our Station Commander had a nervous breakdown and disappeared. It happened again some years later when I was at Waddington; during my two years there as a Squadron Commander, two other Wing Commanders had nervous breakdowns and, during an earlier stint, as a Squadron Leader, a Staff Officer to SASO at Strike Command. These things seemed to be happening to Wing Commanders and Group Captains right across the service. Looking back on it now, one can see that the real pressures were applied at the Wing Commander/Group Captain level.[65]

Perhaps the strain at relatively senior level centred on the flaws in the system: the exposure to destruction on the ground and the endless penny-pinching as the V-Force struggled to deliver its mission. Even the fundamentals came under threat. The 1962 Defence Review estimated V-Force expenditure in the coming decade at around £500 million. The deterrent was under constant scrutiny by those searching for potential savings. Many battles were fought to protect essentials, including dispersal across 36 airfields. This plan was defended in a September 1962 Air Ministry position paper.

[65] Air Vice-Marshal Nigel Baldwin, afternoon discussion, RAF Historical Society meeting, *Journal 26* (2001), 93-97.

This looked at the worst case – IRBMs fired on low trajectory and no "American warning" but, rather, 4-6 minutes – yet still using frequently-assumed escape probabilities, based on all dispersed aircraft at Cockpit Readiness or even RS02. However, this paper made the point that full dispersal was crucial if even a few aircraft were to escape destruction. It argued that fewer airfields would likely increase the number of missiles targeted on each airfield and widen the area of destruction around each base: "If the area of destruction is allowed to extend beyond a certain point, it will be impossible for any bombers to fly clear in time, however rapid their reaction … 36 dispersal airfields are the fewest which will afford a reasonable minimum of immunity to pre-emptive attack …"[66]

It must have been taxing to constantly engage in "combat" with those holding the purse-strings. There is a tone of exasperation in the paper's reference to SACEUR TBF Valiants concentrated at Marham: "To keep 24 aircraft and their associated nuclear weapons concentrated at a single airfield makes no military sense at all …" Indeed, it argued that this made a case for *increasing* the number of dispersal airfields beyond 36 (whilst, at the same time, recognising the limits imposed by economics and availability). Nevertheless, it noted that the Air Staff had decided to add the Valiants to the dispersal force. However, adding TBF Valiants to dispersal detachments (setting aside issues with E weapons) could have had the effect of reducing the survival chances of MBF Vulcans and Victors (unless the Valiants were always last in the queue to take-off). In conclusion, the Air Ministry paper warned that any savings from reducing the number of dispersal airfields would be very small – a fraction of 1% of total investment in the V-Force – and would cause "extremely heavy" operational penalties.[67]

As for frontline aircrew, at least they had the release of flying, including "Ranger" flights overseas and occasional air defence exercises at home and abroad. Testing the ability to defend UK airspace and Bomber Command's operational capabilities offered crews added interest and experience, but the number and scale of these exercises declined sharply. Overall, there was a steep fall in the flying effort, duration and exercise area from the late 1940s to mid-1960s. There were 600 sorties in 1948,

[66] AIR 20/11448, Air Ministry, V-bomber dispersal: "The case for 36 dispersal airfields," September 11 1962, and associated note, September 13 1962.
[67] Ibid.

a peak of over 1,000 in 1955, then a slump to only 40 sorties flown in 1964, in a single "raid"[68]. One problem here was the massive growth in civilian air traffic.

Mock attacks on the UK were always impressive in the early days, as recalled by V-Force Captain John Laycock: "We'd have 20 aircraft in line astern, at 10-mile intervals, flying up the North Sea. They would all turn west and begin to head towards their UK targets. The Hunters and Javelins would then come up and try to intercept us." Infra-red (IR) decoys had proved very effective in fighter affiliation: "The flares were fantastic. If we were unlucky enough to get a fighter approach from the rear and lock-on with a heat-seeker, the flares would almost certainly have proved successful." Lively encounters provided an outlet for "frontline stress" and were not confined to "friendlies". John Laycock recounts a brush with the Russians: "I'd heard that one RAF Pilot on a special mission had been chased by a Russian fighter over the Barents Sea. The V-bomber was on a maritime reconnaissance mission and was over international waters. The Vulcan was light, with around half a fuel-load. When the MiG-21 FISHBED approached, the Captain just pulled the Vulcan into a vertical climb, on full power, and put a wing over. He ended up behind the MiG-21!"[69]

In summary, the first measure of MBF operational effectiveness was the ability of the V-bombers to survive a missile attack on their airfields in sufficient numbers to deliver the core retaliatory threat: dropping several megatons on Moscow and Leningrad, the Soviet Union's first and second cities. Having examined the IRBM threat in relation to MBF Alert and Readiness capabilities – and assuming sufficient strategic warning – the content of this chapter and preceding chapters offers strong grounds for concluding that Alert Condition 1 (with one-third of dispersed aircraft manned 24/7 at Cockpit Readiness, ready for engine start) would allow a small group of V-bombers to survive a missile strike and proceed with a retaliatory war sortie. This chapter also identified serious Bomber Command failures to apply ORB findings fundamental to war scramble survival (especially the need to climb immediately following take-off and enter dedicated "flyaway cones", to avoid random bunching).

[68] AIR 14/4122, Bomber Command, Operational Research Branch, Memorandum No. 301, "Air exercises and operational research in Bomber Command", August 1964.
[69] John Laycock, Victor Captain; Vulcan Captain; interviewed: 27/3/18.

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VULNERABILITIES IN THE AIR: SOVIET AIR DEFENCES

This is the first of three chapters examining MBF vulnerabilities in the air and assessing the ability of a small group of MBF survivors to penetrate Soviet airspace and successfully release weapons on targets. Soviet SAM, fighter and gun defences are considered in this chapter, as is the nature of the challenge presented by low level nuclear strike.

PVO's air defence network

PVO-Strany, the Soviet air defence service, controlled a layered defence: SAMs, fighters, guns and early warning, target acquisition, tracking and fire control radars. Hewson (2008) noted that during the 1940s and 1950s, "Russia actually spent far more on building its air defence system than it did on nuclear weapons … For the modest number of British V-bombers faced with a massive array of Soviet air defences, there was no guarantee of survival at all."[1]

Initially PVO focused on point defence of cities threatened by high-flying bombers. A parallel Soviet programme sought to develop ABM capability. PVO's defence against bombers was based on high altitude SA-2 SAMs and fighters under close control. It built a coastal defence belt of SAMs with fighter barrier patrols in front and behind, area defence by long-endurance fighters, mobile SAM sites and gun batteries, and concentric rings of point defence SAMs protecting cities and other vital targets. Surveillance flights provided ample evidence of rapid air defence build-up. As Jones (1999) observed, the RAF recognised that "it would be increasingly difficult for bombers to get to the cities, at least at high altitude and subsonic speeds …"[2]

Following the loss of Gary Powers' U.2 and, subsequently, cancellation of Skybolt, the V-Force went low level, presenting PVO with a novel challenge. It would take years to reconfigure defences built largely to combat high level attackers. Gradually, however, Soviet SAMs and fighters with low level capabilities emerged – the SA-3

[1] Robert Hewson, "Soviet threat and countermeasures". In *V-Force: ready for the unthinkable* (London: Newsdesk Communications, 2008), 16-17.
[2] Peter Jones, CB, former Director, AWRE, "The history of the UK strategic deterrent," Royal Aeronautical Society, London, March 17 1999.

GOA missile became a significant threat to low level penetrators. The V-Force responded with extreme combat tactics – attacking below 300 ft. This was regarded as an effective counter to improving Soviet defences (which would almost certainly suffer severe degradation in an initial missile exchange). In 1980 there were still 2,000 GOA launchers in PVO's inventory.[3]

Ultra-low penetrators would dip below SA-3's envelope; both SAMs and guns would have extremely brief engagement windows. Soviet fighters were dismissed as having little or no ultra-low capability. Low level strike appeared to offer the MBF a meaningful life extension. Nav/Radar Roy Brocklebank recalls a practical demonstration:

> At our ECM lecture on 230 OCU in 1964 the AEO lecturer started with an OHP display – just the square with the white light on the screen. "This is the cover from just four BAR LOCK radars at high level." He then took a bag of one penny pieces and put them on the OHP. There were lots of white gaps. This illustrated graphically just how many radars would be needed to give radar cover at low level and, even so, there were gaps.[4]

Bomber Command studies (described later in this narrative) demonstrated that, outside the target area, interception of low level bombers remained largely a matter of chance. Past experience of low level attack underlined the advantage of flying raids with single aircraft, going as low as possible and avoiding chance sightings by keeping clear of airfields and targets other than the desired target. Risks increased with penetration distance; attack routes had to reflect the point where the target could be reached by the shortest penetration.[5] A 1962 US study commented on rapidly expanding Russian air defences:

> The USSR has continued to devote large-scale efforts to improving and modernising its air defence system. We estimate that, in recent years, air defence has absorbed about one fifth of the Soviet military expenditure … Defences against hostile aircraft, especially against medium and high altitude bombers, have been greatly strengthened in recent years by the widespread deployment of SAM systems, improved interceptors with AAMs (Air-to-Air Missiles) and advanced equipment for air defence warning and control. For defence against aircraft, the Soviets now rely primarily upon SAMs employed near important fixed targets, and upon fighters deployed to cover approach routes as well as gaps between missile-defended locations. We estimate that, in mid-1962, SAM sites were operational in defence of more than 200 target areas in the USSR, including principal cities and other targets of economic and

[3] "The development of Soviet air defense doctrine and practice," Historical Evaluation & Research Organisation, for Sandia National Laboratories, SAND 80-7146/1, April 1981: 92.
[4] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 22/3/21.
[5] AIR 14/4344, Bomber Command, Operational Research Branch, Memorandum No.275, "The vulnerability of strike aircraft during low level penetration of enemy defences," September 1963.

> military importance … we estimate that in mid-1962 about 750 sites were operational … we now estimate that the Soviets will deploy a total of some 1,000-1,200 SA-2 sites in the USSR.[6]

In 1971, just over a decade after Gary Powers' U.2 was shot down, an Air Force Department paper commented:

> In the Western Air Defence Districts of the USSR, there is a total of 738 SAM sites and 2,423 aircraft in the air defence role. In addition, there are some 4,000 AAA (Anti-Aircraft-Artillery) guns belonging to the Army … At first sight, the sheer numbers of the air defence weapons systems appear to be formidable, but these must be seen in perspective against the vast geographical area of the country, which tends to dilute the overall defensive capability and to force a concentration of effort in the more sensitive areas.[7]

Countering the high-flying bomber

During the 1950s, No. 90 Signals Group's four squadrons of Lincolns, Washingtons, Mosquitos and, later, Canberras and Meteors, flew sorties structured to provoke Soviet air defence reaction. The aim was to find out "as much as possible about the defensive radar system ranged along the borders of the USSR and its Warsaw Pact allies and around high-value point targets …"[8]

The missions probed for gaps in coverage and attempted to identify how long the defences took to respond to a threat, how Command and Control was exercised and information on the specific characteristics of each radar type. By the mid-1950s, specially-equipped Valiants began exploring Soviet defences.[9]

PVO's early development involved extending ground-based defences to ever higher altitudes and, secondly, deploying a force of heavily-armed jet interceptors. The threat was from individual or small cell penetrators. Milestones included entry into service of the SA-1 and SA-2 SAMs (1956 and 1958 respectively) and the Su-9 fighter (1959). PVO concentrated on all-weather interceptors, mostly equipped with two AAMs (indicating the dominance of single, close interceptions as another layer to SAM point defences). A RAND paper by James T. Quinlivan (1989) noted:

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[6] **"**Soviet Bloc air and missile defense capabilities through mid-1967," *National Intelligence Estimate Number 11-3-62*, October 31 1962.
[7] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[8] Wing Commander David Paton, "Airborne electronic reconnaissance, 1948-1989", RAF Historical Society, *Journal 23* (2001): 59-68.
[9] Ibid.

> High altitude bomber penetration could be aided by electronic countermeasures against the radars of aircraft and SAMs, but the appearance of nuclear warheads at SAM sites made it clear that ECM would be a winner at high altitude only if it could induce large miss distances. In the West there was general agreement that subsonic high-flyers were obsolete.[10]

Quinlivan added that PVO was confident of delivering point defence against high-flying penetrators. Border SAM belts and coastal airfields provided barrier defence, while an enlarged radar network and improved data handling "provided a true zone defense". This assumed penetrators would fly high enough and remain within individual radar coverage long enough to allow completion of an interception. Soviet estimates of their own capability against high altitude penetrators were high: "Yugoslav planning factors for the probability-of-kill of SA-2s … were 0.8."[11]

Countering low level penetrators

USAF and RAF planners had long recognised that new weapons and tactics were required to penetrate mature SAM defences. The weapon of choice was the stand-off ASM – preferably released in undefended airspace – such as the American Hound Dog and the British Blue Steel. Quinlivan noted that, during the same period, "both air forces also introduced low altitude bomber penetration tactics – tactics which did not rely on technology as much as the skill and courage of the aircrew." The Russians, very probably, could have coped with the stand-off ranges of first generation stand-off weapons, had the carriers remained at high altitude, but low level penetration changed that completely:

> The RAF low-level penetrator threat against the Soviet Union dates from the early 1960s, when the Valiant component of the British V-bomber force was assigned to operational control of SACEUR. Rather than modernize the Valiants with ECM equipment intended to retain a high altitude penetration capability, the Valiants were given a low altitude penetration mission … SAC introduced low altitude training flights in 1959 … The low altitude penetrator completely negated the PVO system of defense. The then current SA-2 variant probably had no capability whatsoever against aircraft below 5,000 ft. The interceptors then in inventory had no ability to "look down" and detect bombers flying against an earth background. But the situation was even more complicated for the interceptor force than the end-game detection. The limited time a low-level penetrator would be within the horizon-limited detection range of any particular radar precluded the launch and vectoring of an interceptor from ground alert. Given the limited endurance of the interceptors then in the

[10] James T. Quinlivan, "Soviet strategic air defense: a long past and an uncertain future", AD-A228-306, paper, The RAND Corporation, September 1989: 10.
[11] Ibid, 10-11.

> inventory, Soviet interceptors could only carry out intercepts from ground alert, rather than an airborne CAP (Combat Air Patrol). [12]

SAM defences

The Russians responded to the low level threat with large-scale deployment of the SA-3 SAM, with low altitude capability, to reinforce both point and barrier defences. James T. Quinlivan observed that the SA-3 role was to re-establish point defence against low level penetrators:

> In order to cover a fixed site against low altitude penetrators, many SA-3 launchers and engagement radars were required. Such a defense had the disadvantage that the horizon-limited detection and even smaller engagement radius guaranteed only a single engagement with a transiting bomber. This limited engagement opportunity contrasted with the multiple engagement opportunities high-flying penetrators provided to SA-1s and SA-2s. Modifications to existing SA-2s … included changes in the fire control to accommodate optical guidance and improve low altitude performance. Meanwhile, the low maximum altitude capability of the SA-3 (about 40,000 ft) demanded that high altitude SAMs be kept in place because penetrating bombers could still penetrate at high altitude if the Soviets did not defend that altitude band.[13]

PVO's requirement for a SAM capable of engaging both high altitude and low level penetrators was issued in the late 1960s/early 1970s but the resulting SA-10 GRUMBLE was not deployed until 1980. This system combined the capabilities of SA-2 and SA-3.[14]

In its paper to the Long Term Strategic Nuclear Working Party in 1971, the Air Force Department was extraordinarily optimistic about the Vulcan's ability to survive a dense SAM environment (even allowing for the fact that this paper was part of a submission advocating a future British air-delivered weapons system, in a world long dominated by ballistic missiles):

> Against SAM defences, the Vulcan's chances of penetration are high; the only SAM credited with a kill capability at the height at which the Vulcans would fly is SA-3. The engagement zone at 500 ft is between 3.3 and 5.7NM and the single shot probability of killing an aircraft penetrating this zone is about 0.2, given an alerted SAM crew. For an aircraft at 300 ft, the height which the Vulcan would maintain over sea or reasonably flat terrain by night or in IMC (Instrument Meteorological Conditions), the probability is, at most, 0.05 and this would require ideal conditions for the SAM crew, such as:

[12] Ibid, 11.
[13] Ibid, 12-13.
[14] Ibid, 15-16.

1. An alert and well-trained crew.
2. A good early warning "feed-in".
3. All equipment working perfectly.
4. No terrain-screening of the SAM radar.[15]

> At 200 ft or below, the Vulcan's penetration height in clear day conditions, the SA-3 system would have no capability. The positions of SA-3 sites are known and aircraft would be routed well clear of them whenever possible. At places where they can only be avoided by a narrow margin – on the coast or near the target, for instance – the aircraft would fly as low as possible and certainly not above 300 ft.[16]

Each SA-3 site was capable of launching a salvo of two missiles, the interval between firings in the salvo being around five seconds. A second salvo can be fired after about 30 seconds. This study assumed a complex of five sites for city defence. For a Vulcan flying at night at 500 ft at cruise speed (within the SA-3 threat zone), kill probability for a single SA-3 site was put at 0.46 (or 0.76 for a five-site complex).[17]

Returning to fighters, Julian Grenfell, an electronic warfare (EW) specialist and former Vulcan AEO, reflects: "You should NEVER discount a weapon system because it was said to have no capability … The AEO would be listening to his RWR. He would react to what the RWR was telling him, not to some manual back at base!"[18]

Fighter defences

The breezy, optimistic tone of the 1971 Air Force Department paper continued with regard to fighters:

> … the Soviets lack continuous radar early warning and tracking capabilities at low level for the employment of fighters using the traditional close control technique to which they are wedded; and, secondly, there is no evidence that they operate, exercise or train at heights below 1,500 ft. Thus, on present form and until the Russian fighters show definite signs of really concentrating on low level defence, they do not present a significant threat.[19]

In the paper, fighters were assumed to mount barrier patrols at low level across the direction of threat: "Since they are unable to use their conventional pulse AI radars at

[15] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[16] Ibid, Annex C.
[17] Ibid.
[18] Julian Grenfell, Vulcan AEO; email: 14/4/19.
[19] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.

low level, they would be forced to rely on visual detection, followed by gun or missile attacks, thus limiting any fighter capability to clear daylight conditions."[20]

Julian Grenfell agreed that there were some grounds for optimism as fighters of the late 1960s would have found it difficult to engage a low level, camouflaged and manoeuvring target employing chaff and jammers.[21] However: "Even though the probability was low for engagement by a fighter, it was still a weapon system that would kill you. PVO had lots of fighters!"[22]

James Quinlivan's 1989 paper took a similar line:

> The "look down" problem drew most of the attention. PVO first received the MiG-23, an aircraft developed for the tactical forces, which had a radar with some depressed angle capability. Later, MiG-25 aircraft were modified to the same standard. The modifications improved the end-game performance of the interceptors, assuming the interceptor could be brought to the end-game situation. Providing the interceptor with a "look down/shoot down" capability in the end-game engagement was a challenging technical problem, but it … could be solved given sufficient effort … the results appeared in PVO inventory with the FOXHOUND (MiG-31) and FLANKER (Su-27). A more challenging problem was changing the command and control system so that close control intercepts could be brought to the end-game on the basis of the intermittent coverage of different radars … The most direct approach to solving this problem is the "interneting" of radars so that a penetrator's continuous time in radar coverage is made long enough to permit completion of a controlled intercept.[23]

The Soviets also pushed forward the air defence boundary, perhaps far enough to reach the bombers before they began low level penetration: "That is a reasonable interpretation of the Soviet introduction of the long range Tu-28 FIDDLER and its frequent companion, the Tu-126 MOSS AWACS aircraft, and the preferential basing of the Tu-28s along the northern periphery of the Soviet Union."[24] The Tu-28 was a long-endurance "loiter" supersonic fighter, armed with a powerful radar and long-range AAMs.[25]

Yet, as Vulcan AEO Julian Grenfell points out, Soviet fighter defence in the 1960s allowed individual pilots little freedom of action: "The whole of Soviet air defence was procedural … fighter pilots were not allowed autonomous operation; the Fighter

[20] Ibid.
[21] Julian Grenfell, Vulcan AEO; "Vulcan Paper", notes (undated).
[22] Ibid; email: 14/4/19.
[23] Quinlivan, "Soviet strategic air defense", 13.
[24] Ibid.
[25] Goodall, *My target was Leningrad*, 164.

Controller told the pilot which type of engagement to fly and would state a missile or guns engagement!"[26]

Gun defences

The 1971 Air Force Department paper noted that PVO discarded gun defences (beyond weapons for local site defence) in the early 1960s:

> However, there are a number of Army divisions … in Western USSR Military Districts and these have AAA and SAMs for their own defences. They form part of the second echelon reinforcements for the Soviet forces in East Germany and in crisis or in conflict they would move to the forward areas. It is believed that the guns which are owned by the Army would be taken with them. Nevertheless, to cater for the unlikely event of them staying behind, it is planned to avoid all places where the deployment of any available gun defences would be expected – Army installations, airfields, SAM and radar sites, towns and soft ballistic missile sites.[27]

Low-flying penetrators would have been well-advised to avoid airfields with defences including 57mm S.60 gun batteries, each consisting of six to eight guns, a FIRECAN S-Band fire control radar and a PC6 predictor. A 1968 RAF Strike Command report on defence penetration (in a limited war/non-European context) commented:

> A Soviet fighter airfield battalion consists of three batteries and deployment is normally in a circular pattern … a search radar with a low level capability is associated with each battery, to provide, wherever possible, a degree of radar early warning of target approach … In front of the gunsites, visual observation posts are likely to be established, to supplement radar early warning.[28]

According to this Strike Command study:

> The guns of a Soviet complex would probably open fire at maximum range (about 3NM) by firing in short bursts. This would give the gunner a chance to make any adjustments considered necessary. As the aircraft approaches, the bursts would become longer and, since it is necessary to allow the guns to cool from time to time, the open fire times are staggered so that only one gun at a time need to be stood-down for cooling.[29]

An Annex to the Air Force Department 1971 paper considered the AAA threat in more detail. The Army inventory consisted of 57mm S.60 guns with FIRECAN or

[26] Julian Grenfell, Vulcan AEO; email: 14/4/19.
[27] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[28] DEFE 58/90, "Defence penetration techniques: the problem of defence penetration by Vulcan aircraft at low flight altitudes during a limited conventional conflict in a non-European area", Strike Command Development Unit Report No. 9/68 – Part 1: HQ STC Trial No. 549 Phase C, Annex L, December 31 1968.
[29] Ibid.

FLAPWHEEL radar, the 57mm ZSU/57/2 with no radar, the ZSU/23/4 with GUN DISH radar and the 23mm ZU/23 with no radar. The ZSU/23/4 GUN DISH combination was a major threat to low level attackers but the scale of deployment was unknown at the time of the study.[30]

ZSU/23/4, known by the Soviets as SHILKA, was described in a 1981 Sandia report as "a most impressive and highly dangerous weapon system." While it had a maximum rate of fire of up to 4,000 rounds per minute (1,000 rounds per barrel), "the more practical rate is about 200 rounds per minute per barrel (800 rounds per minute for four barrels) fired in 50-round bursts of about 3¾ seconds."[31]

Most V-bomber aircrew, including Victor Captain John Laycock, had no doubt about the greatest threat: "In penetrating defences, the most dangerous threat was the ZSU four-barrelled cannon – which was bloody lethal. We would be right in its threat zone, at 500 ft or less, and we had no idea where these mobile units would be sited on the day."[32] This weapon's GUN DISH was a J-Band tracking radar; the Vulcan had no J-Band jammer.

This chapter underlines the extraordinarily heavy Soviet investment in air defence, emphasising defence against high altitude bombers. This included mass deployment of SAM batteries. Problems involved in re-configuring these defences to combat a low level nuclear strike threat are recognised, as are some inherent weaknesses – including the absence of effective low level SAM and fighter cover. The challenges also included reducing radar detection and management shortcomings at low level. The SA-3 low level SAM gradually reinforced barrier and point defences and new fighters provided CAP defence with "lookdown" capabilities. British planners, however, took the view that ultra low penetration presented Soviet defenders with a set of problems which could not be resolved.

[30] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[31] "The development of Soviet air defense doctrine and practice", Historical Evaluation & Research Organisation, for Sandia, April 1981: 81.
[32] John Laycock, Victor Captain, Vulcan Captain; interviewed: 27/3/18.

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VULNERABILITIES IN THE AIR: PENETRATING THE DEFENCES

This second chapter on MBF vulnerabilities in the air examines the challenge of penetrating Soviet defences, beginning with the severe risks associated with high altitude attack in daylight. The advantages of low level penetration are discussed. V-Force training for low level strike is reviewed and aircrew views on the chances of successful penetration are presented, together with the difficulties surrounding V-Force ECM.

Getting through to the target

Before the V-Force went low level, the intention was to strike Russia with cells of high-flying bombers benefitting from mutual electronic support. ECM and tactics were tested in "Spellbound" exercises - Bomber Command pitted against Fighter Command. The results were not encouraging, with high levels of ECM unserviceability and poor defensive outcomes. When reporting (April 1961) on the first three trials penetrating UK airspace, Bomber Command Chief Research Officer Tom Kerr made an unusual suggestion: "In these circumstances, we request that this report be shown only to those who have a 'need to know' …"[1] The last Spellbound (14), was flown on April 26 1962; defending fighters intercepted 79% of bombers at least once (two bombers were intercepted four times; only three bombers were not intercepted).[2] As Nav/Radar Roy Brocklebank observed: "…this always presented a problem for analysts. Would the three not intercepted have been intercepted had the overkills not taken place?"[3] With Spellbound completed, Kerr tried to be upbeat. Whilst acknowledging that ECM design faults, unserviceabilities and a shortage of correct aerials marred the first six exercises, he claimed they did much to enhance knowledge of the equipment's servicing and operation.[4]

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[1] AIR 14/4306, Bomber Command, Operational Research Branch, Memorandum No. 223, "Effectiveness of the Red Shrimp jammer in Exercises Spellbound 1, 2 and 3", April 1961.
[2] AIR 14/4318, Bomber Command, Operational Research Branch, Memorandum No. 249, "Performance of ECM in Exercise Spellbound 14", June 1962.
[3] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.
[4] AIR 14/4313, Bomber Command, Operational Research Branch, Memorandum No. 243, "Performance of ECM in Exercise Spellbound", August 1962.

Poor Spellbound outcomes and problems with ECM and Window were not shared with V-Force crews. However, everyone must have known that prospects were grim for high altitude penetration. Then came the dramatic move from 50,000 ft plus to 500 ft and lower. Whilst aircraft and weapons had changed radically over two decades, a Bomber Command study suggested the fundamentals governing survival at low level in enemy airspace were little changed since World War 2. This September 1963 memorandum was issued as V-bombers were switching to low level strike. The study drew heavily on experience in World War 2, together with the outcome of post-war exercises: "No attempt has been made to assess the effectiveness of modern air defences against low-flying aircraft, but most of the problems existing 10 and 20 years ago are still present."[5]

Losses to fighters were governed by raid size and penetration depth. Loss rates for raids of 20 or more aircraft were "appreciably greater" than for single aircraft (with small groups of up to five aircraft suffering no greater losses than single aircraft). Post-war attempts at close control of fighters as low level interceptors achieved little success:

> Chance appears to play a very large part in the success of fighters in intercepting low level aircraft. It follows that the greater the density of fighters in the area of low level operations, the greater is the risk to the attacking aircraft. In particular, the post-war exercises have demonstrated how, by avoiding fighter airfields by 10-20 miles, the interception rate is reduced considerably.[6]

The effects of height on risk exposure were difficult to assess, but "there appears to be no real variation in the losses suffered for aircraft flying between 100 and 500 ft." This view was modified when the SA-3 low level-capable SAM was deployed.[7]

On penetration depth, post-war exercises revealed that "the interception risk per 10 miles of penetration by a low-flying bomber is 0.04 when the targets are airfields and 0.01 when non-airfield targets are attacked and when airfields are avoided by at least 20 miles on the route to the target." This was based on an average fighter density of three per 100 square miles, an efficient ground observer network providing raid reporting and no precision type of control but provision of raid information allowing more efficient defence patrols. Lack of a ground observer network reduced

[5] AIR 14/4344, Bomber Command, Operational Research Branch, Memorandum No. 275, "The vulnerability of strike aircraft during low level penetration of enemy defences", September 1963.
[6] Ibid.
[7] Ibid.

interception risk by a factor of three. Interceptions and combat losses, of course, are different things: “With the present-day fighter armament, the probability of converting an interception into a successful combat will lie somewhere between 10% and 40%.”[8]

Whilst this study was, essentially, an historical review, few challenges for the defences had been solved by 1963: “The only parameter which has shown any change … has been an increase in speed, which is more marked in the case of defending fighters than that of the attacking bombers.”[9] Yet this comment excluded another change of major consequence – the immeasurably greater destructive power of the weapons carried and, thus, the extraordinarily high price of failure to intercept *and kill each penetrator* before weapon release.

This study made a powerful case for low level attack. In a non-ECM environment, a single high level aircraft runs a 95% interception risk after 250 miles’ penetration of radar cover. In contrast, “there has been no progress whatever in the precision control of fighters at low level. Low level fighter defence appears to be still essentially one of barrier patrols and of patrols in the target area.” Naturally, low level deep penetrators surviving the attack phase then faced continued exposure during recovery, perhaps aggravated by the need to climb to conserve fuel. At the same time, kills made after weapon release were valueless in the context of a one-strike nuclear attack. Furthermore, this report did not consider the rapid growth in Soviet SAM defences - as the review was essentially historical and, at that time, the bulk of SAM defences consisted of high altitude SA-2 sites. Nevertheless, it added that “in the future this type of defence will probably constitute the greatest threat to low level aircraft.”[10] In the V-Force, 500 ft would soon be regarded as dangerously high.

According to this report, the main lessons for low level strike were: fly raids with single aircraft, fly as low as possible and confound raid reporting and avoid chance sightings to the maximum degree by keeping away from airfields and targets other than the desired target. As for the results of post-war exercises, an Appendix commented: “There is considerable evidence to state that interception of low level aircraft is a matter of chance, the risks increasing with penetration. Against non-airfield targets, the risk was 5% per 50 miles of penetration.”[11]

[8] Ibid.
[9] Ibid.
[10] Ibid.
[11] Ibid.

Could the V-Force succeed?

There was always an undercurrent of doubt as to whether the V-Force could survive a pre-emptive missile strike with sufficient strength to go on and deliver a meaningful retaliatory attack. Yet, in June 1961 Air Vice-Marshal T.O. Prickett, ACAS (Ops), presented a gleaming vision of the V-Force. In a "Guidance Memorandum" circulated to all Commands, he wrote: "The V-bombers have no superior in the world today among bombers of their range, and the present defence system of the potential adversary could not hope to seal off his vast airspace so completely as to prevent enough of them striking home to wreak enormous damage."[12]

Prickett's note acknowledged that point protection of vital targets "is bound to become more effective"; entry into service of Blue Steel would meet this challenge and provide "continuing validity". He then added: "We must expect that eventually the effectiveness of the opposing defences will further develop to a point where even area penetration will become very difficult and costly." However, at this time Skybolt was still in prospect – a solution avoiding penetration of defended airspace: "With this weapon, to which no practicable defence is in prospect, the V-bombers' ability to hit their targets will be preserved until at least the end of the decade."[13] While Prickett lauded the power of the V-Force, he ignored the fact that, in a Cold War turned hot, most of its strength would be vaporised on the ground, or destroyed in the air, in the immediate vicinity of its airfields.

Low level penetration

Crews accustomed to flying at over 50,000 ft were suddenly flying very low in large aircraft designed to do exactly the opposite. Many relished the challenge. Air Commodore Norman Bonnor, then a Victor Nav/Radar, described a typical hi-lo-hi training flight for Blue Steel-armed aircraft: a climb to 45,000 ft and a 1,000NM high level navigation exercise (Navex), followed by the descent for a 500NM low level Navex (250/350 kts at less than 500 ft, including a simulated missile launch at 300 ft) and a high level recovery leg.[14]

[12] AIR 19/727, "The Deterrent Policy", Air Vice-Marshal T.O. Prickett, ACAS (Ops.), Guidance Memorandum, June 13 1961.
[13] Ibid.
[14] Norman Bonnor, Victor Nav/Radar; paper: "Blue Steel - the V-Force's stand-off bomb" (undated).

Successful low level attack depended on V-bomber aircrew accepting the inherent risks of training for war at 300 ft or lower. “Low flying” was a flexible term – much depended on the Captain’s attitude and the confidence and experience of his crew. Vulcan Captain Nick Dennis describes the challenge:

> When low flying at night we would be at 100 ft, with the Nav/Radar giving a running commentary. If Terrain-Following Radar (TFR) had been introduced earlier, it would have saved lives. When we eventually got TFR, it was basic – just a yellow indicator on the Director Horizon, oscillating as the terrain changed. It was very difficult to follow with any accuracy. Tragically, one crew hit the top of the Brecon Beacons … flying in white-out conditions without TFR.[15]

Vulcan Nav/Radar John Weller’s crew were confident of flying a successful war sortie: “We would be very low, using TFR, although we didn’t fly lower than 500 ft at night in peacetime. I think our chances would have been improved by weapons detonating… with the EMP (electro-magnetic pulse) knocking out many of their radars.”[16]

Many recall the excitement of flying ultra-low over the Arctic tundra of Goose Bay, Labrador. Wing Commander Peter West was a 12 Squadron AEO. His Captain, then Squadron Commander Bob Tanner, took “low level” literally: “When we flew low, we never went higher than 250 ft; Bob preferred 110 ft during our regular visits to Goose Bay – ‘footloose on the Goose’”.[17]

Nav/Radar Jim Walker and crew did a great deal of low flying in Vulcan Mk. 1As: “Initially, we flew at 500 ft, or 1,000 ft at night. Things were different when we reached Goose Bay.” His Captain, Mike D’Arcy, went down as low as 50 ft! “When we flew over the sea, we picked up a crust of salt.” His other Captains had different ideas: “My second Captain was more cautious than D’Arcy and the third was more nervous. Anyway, we were cleared to fly down to 250 ft at 375 kts on occasions, such as in major exercises.” D’Arcy and crew didn’t think much of the “2H” attack - the “pop-up” with Yellow Sun 2. Jim Walker felt that would have been pretty dangerous. The danger remained when WE.177B arrived; it would have been dropped in a “2F” attack whilst directly overflying the target:

> We would have been travelling at 600 ft per second and reckoned to be six miles away at detonation. I always understood we would keep low, going flat out, rather than make an attempt to climb out. If the weapon airburst, you

[15] Nick Dennis, Vulcan Captain; interviewed: 30/5/18.
[16] John Weller, Vulcan Nav/Radar; interviewed: 1/8/18.
[17] Peter West, Valiant/Vulcan AEO; interviewed: 30/4/19.

> couldn't get away. However, we were going for a WE.177 groundburst and this would have contained the energy to some degree.[18]

A late 1960s Strike Command report on low level penetration by the Vulcan force recognised the difference between a war sortie taking the aircraft to its performance limits and "acceptable training levels which will be based upon a performance envelope lying well inside the maximum permissible limits." This study concerned penetration in conventional, non-European conflicts. It assumed a range of speeds, from about 225 kts to 375 kts IAS (Indicated Air Speed), and that aircraft endurance would give a degree of freedom of choice of penetration route. As for minimum height, Vickers Armstrong studied risk at a nominal clearance height of 200 ft during work on the TSR.2 programme, given a peacetime criterion of terrain-following being permitted to cause only a 5% increase in aircraft accident rate from all causes. This concluded that 150 ft could be satisfactory on the same basis or even 100 ft could be acceptable for peacetime flying, given system developments. The Strike Command Development Unit commented: "… it seems reasonable to conclude that the safe clearance altitude is a function of aircraft speed and that an altitude of 200 ft at a speed of M.0.5 should be possible for short periods, with 300 ft sustainable for longer periods of time."[19]

Going in

Crews had a variety of views on the chance of successful penetration. Vulcan Navigator Paul Hickley (2014) thought it would have been "extremely easy", as "certainly in the 1960s, 1,000 Minuteman and Atlas missiles would have arrived two hours before the V-Force and the Soviet Union would have been a smoking ruin …"[20] A July 1963 Bomber Command study gave an opinion: "The targeting of ICBMs is now so extensive that missile strikes on or near the QRA targets can be expected and the effectiveness of the defences – both fighters and SAMs – considerably weakened."[21] As for whatever defensive capability remained, EW specialist Julian Grenfell pointed out: "Going low dramatically reduced the early warning range … The early warning radar's intermittent 'paints' of the target made the handover to acquisition radars more difficult, while height-finding and tracking by fire control radar

[18] Jim Walker, Vulcan Nav/Radar; interviewed: 26/3/19.
[19] DEFE 58/90, "Defence penetration techniques", Strike Command Development Unit Report No. 9/68 – Part 1: HQ STC Trial No. 549, Phase C, December 1968.
[20] Paul Hickley, Vulcan Navigator, "Defence through deterrence: British policy during the 1960s and 1970s", Witness Seminar, Institute of Contemporary British History and Defence Studies Department, King's College, London, September 10 2014.
[21] AIR 14/4341, Bomber Command, Operational Research Branch, Memorandum No. 272, "Blue Steel and QRA," July 1963.

was more difficult, as SA-2 could not engage lower than 5,000 ft, but this was much reduced later."[22] Grenfell acknowledged that SA-3 GOA did much to plug the gap.

The fact remained, however, that penetration of hostile airspace, flying ultra-low across a country submerged in a tidal wave of nuclear bombardment, would test even the most courageous to the very limit. Valiant Co-Pilot Dick Fuller harboured profound doubts about hi-lo-hi:

> Our range gave a maximum flight time of around seven hours, but when you fly low you burn fuel at one hell of a rate. All our targets were in Western Russia and I didn't have much hope of us penetrating successfully. Naturally, our routes in were based on Intelligence and designed to avoid the defences, but I was more worried about the flashes and clouds from other bombs. After all, many important targets were earmarked for multiple strikes. As for getting back, we were supposed to return to Marham. We didn't give that much thought. Certainly, we all believed that the losses going in and coming out would be tremendous. There was a tendency to over-estimate the capabilities of the Soviet air defences – we gave them credit for being a lot better than they were. Nevertheless, our Valiants were sitting ducks.[23]

The 1971 Air Force Department paper for the Long Term Strategic Nuclear Working Party offered views on the likely effectiveness of a V-Force strike: "Taking into account all the potential capabilities of the Russian air defence systems, the probability of a single aircraft surviving each type of defence and reaching its target has been calculated." This paper included a table referring to "four representative – but not particularly easy – targets which are at present allocated to the RAF alone." Target identities were removed from the source document, imposing obvious difficulties in interpretation. Single aircraft survival probabilities were given as follows:

Penetration distance	**SA-3**	**Fighters (by day only)**	**Guns**	**Overall**
215NM	1.0	0.61	0.98	0.60
530NM	1.0	0.36	0.95	0.34
450NM	1.0	0.60	0.96	0.57
105NM	0.98	0.73	1.0	0.71 [24]

SAM casualties, according to this study, would be almost non-existent at extreme low level. In addition, this paper stressed lack of evidence for Soviet fighters operating below 1,500 ft. The assumptions on Soviet fighter defences are those in the 1971

[22] Julian Grenfell, Vulcan AEO; "Vulcan Paper", notes (undated).
[23] Dick Fuller, Valiant Co-Pilot; amongst documents/text provided: 29/10/20.
[24] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971, Annex A.

National Retaliatory War Plan, but with numbers and types of fighters at each base updated. These changes were minor, requiring no recalculation of losses to fighters. This included the following combat lethalities:

- Pair of gun-armed fighters: 0.40
- Single gun-armed fighter: 0.23
- Fighter with two AAMs (other than ALKALI): 0.22
- Fighter with four AAMs (other than ALKALI): 0.35
- Fighter with four ALKALI missiles: 0.08.[25]

The problems with the 1971 paper are that, on the one hand, it was "selling" a future air-delivered system to succeed Polaris and, thus, had every reason to present optimistic views on the chances of survival and successful penetration by ageing Vulcans, whilst, at the same time, skirting the problem of allowing for severe degradation of the Soviet defences following a retaliatory missile strike. Here, the paper offered a bare comment, ignoring the full weight of the Western missile strike (but relevant post-1969 in a unilateral response): "It is believed that Polaris strikes would have little effect on anti-aircraft defences."[26]

James T. Quinlivan (1989) provided a wider view of the missile threat to Soviet air defences:

> In 1964 the SAC ICBM force of 931 missiles first equalled the alert bomber force. Besides representing a significant change in the form of a strategic attack, the missile force presented a new threat to the operating environment of the air defense. Missile attacks presented the Soviet air defense with the question, "What, exactly, would be left for a strategic air defense to defend after an initial missile exchange?"… PVO would thus have to survive an initial suppression attack before it could begin its defense of the homeland. PVO ability to survive a nuclear missile attack was problematic.[27]

In assessing the Vulcan's ability to penetrate Soviet defences in the early 1970s, the Air Force Department's paper assumed adverse conditions for survival: daylight and good visibility. Yet, it remained upbeat. Ignoring the main problem – launching successfully – it claimed: "… in spite of the nature and numbers of the Soviet air

[25] Ibid, Annex A, Appendix D.
[26] Ibid, Annex A.
[27] James T. Quinlivan, "Soviet strategic air defense", The RAND Corporation, September 1989: 14.

defence weapons systems, it is possible for the aircraft to penetrate to their targets with a good chance of delivering at least one weapon on each."[28]

Penetration by day

There was always an acute awareness of greater risk to the V-bombers in daylight. For some years, exercises with UK home defence fighters produced alarming results for daylight penetrators. In October 1958, for example, Exercise Sunbeam involved several attempts to break through the fighter defences. It was a major exercise, involving 150-300 aircraft attacking the UK east coast in waves, from north of the Thames to the Orkneys. The raiders included aircraft from Bomber Command, 3rd Air Force, 2nd Allied Tactical Air Force (ATAF), 4th ATAF and NATO national air forces. Bomber Command participated in all six day raids, flying 16 Valiant and 70 Canberra sorties, with no ECM, at heights from 37,000 ft to 45,000 ft, and opposed by Hunters and Javelins. The results were shocking, providing real evidence that the Valiants were, indeed, "sitting ducks". Bomber Command's report faced the truth: "There is no doubt that under the conditions of this exercise the fighter defences were able to intercept some 90% of the attacking Bomber Command aircraft. This is the highest average interception rate in any peacetime exercise."[29] The figure for the preceding year (Exercise Vigilant, 1957) was 44%.

There were just two Valiant day raids (both on the first day): "… the Canberra and Valiant raids penetrated in the same general area but whereas the Valiants suffered 100% interception, only 70% of the Canberras were intercepted … the most striking difference lies in the number of interceptions reported by the aircraft. Valiants reported 3.1 interceptions each, whereas the Canberras reported only 1.2 interceptions per aircraft." This was attributed largely to the greater visibility of the anti-flash white-painted Valiants.[30]

This 1959 report on Sunbeam concluded:

> The conversion of such an interception rate into "losses" is a matter of speculation. With conventional gun armament, the lethality of combat is expected to be in the region of 0.2 to 0.3. Bearing in mind the multiple interceptions which were effected (average of 2.3 per bomber) the "kill" rates

[28] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[29] AIR 14/4283, Bomber Command, Operational Research Branch, Memorandum No.192, "The interception of Bomber Command day raids in Exercise Sunbeam," March 1959.
[30] Ibid.

> would have been high, around 50% … The worst "losses" would have been a raid of six Canberras, where one or none of the aircraft would have survived. [31]

The report acknowledged that "from the bombers' viewpoint, the above conclusions are very pessimistic." Some factors, however, worked in favour of the defences: no ECM, no concentration - in an attempt to swamp defences - and raid times were generally known and repetitive (although impact on the 90% interception rate "would be a matter of conjecture."). [32]

When using ECM, chaff, decoys and vigorous evasive manoeuvres in affiliations with fighters, it could be a different story for the more advanced and powerful V-bombers, although they were increasingly vulnerable to SAMs whilst at high altitude in the early 1960s. The Vulcan, extraordinarily manoeuvrable at high altitude, also held unpleasant surprises for fighters at low level. AEO Peter West discussed high level performance:

> A Vulcan at high level could out-manoeuvre any fighter. Whether high or low, however, it was hard to break missile lock. Nevertheless, a decent Pilot and AEO certainly had a chance. On one occasion, flying with Bob Tanner on a fighter affiliation, we were limited to "gentle manoeuvring" at no higher than 40,000 ft. At a certain point the Sea Vixen Pilot said he had to return due to his fuel state. Bob asked him whether he fancied an all-out last go. Bob then got onto the fighter's tail and, once there, the Sea Vixen couldn't shake us off. [33]

Equally, the Vulcan could be highly aggressive when low. Nav/Radar Roy Brocklebank recalls its ability to turn the tables on an attacking fighter:

> When at Waddington, our Vulcans practised evasive manoeuvres when chased by Sea Vixens. The Sea Vixen would come up behind the Vulcan. It would be detected by the Red Steer Mk.2 tail-warning radar … We would wait until the simulated missile launch was detected, then drop chaff and decoys, go into a rapid climb to at least 1,000 ft, execute a 90 deg. turn and then return to very low level before reverting to the original track. We would leave behind a bank of violent turbulence. During the trials of this evasive manoeuvre, the turbulence was found to be powerful enough to flip the following Sea Vixen onto its back. [34]

Visual contact was the key to low level detection in daylight. Here, the Vulcans had the disadvantage of trailing black smoke. A solution was sought; 617 Squadron's Operations Record Book for August 1968 noted trials with "Lubrisol", a smoke

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[31] Ibid.
[32] Ibid.
[33] Peter West, Valiant/Vulcan AEO; interviewed: 30/4/19.
[34] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.

suppression product. An American fluid, CI2, was also tested; it was said to have been used with considerable success in Vietnam.[35]

This had major significance for daylight survival; Russian fighter pilots with expended armament were expected to ram bombers. A Soviet document on air defence (1958) had a section on ramming:

> … Soviet military doctrine requires the destruction of the enemy without fail before he reaches his target … atomic and hydrogen bombing is a question of life and death for the great masses; therefore, it must be averted at any price, under any conditions … the Soviet fighter pilot must resort to ramming. If he does not resort to ramming, his commander can "recommend" it to him.[36]

Penetration by night

V-bombers had a better chance of successful penetration at night and/or in bad weather. They became increasingly vulnerable by day during the 1960s, but retained potency at night for many years – well into the 1970s. The point was made, in convincing style, by V-Force aircraft participating in the USAF's "Red Flag", widely regarded as the most realistic simulated combat flying environment anywhere in the West. The positive outcomes achieved by British crews flying obsolescent aircraft with aging equipment during the 1970s support the view that V-bombers would have been even more capable at night during the preceding decade.

Roger Dunsford flew Vulcans during the 1973-84 period. In 1978 he was Captain of an elite "Command" crew with 44 (Rhodesia) Squadron. They were selected for Strike Command's Red Flag team, to fly against the best weapon systems fielded by the Soviet Union in the late 1970s:

> My logbook shows that we flew a night Red Flag exercise in the United States starting on November 27 1978 – pretty late in the Vulcan's life, when many considered it obsolescent, if not obsolete. This was centred on Nellis AFB, Nevada. The opposition came from fighters of the USAF "Aggressor Squadron", which made use of Soviet radar technology and tactics in simulating Soviet aircraft. There were "Soviet" SAM and gun batteries out in the desert, similarly trained and equipped to complete the full suite of Soviet air defences... Four Vulcans flew that exercise and all four "delivered" their weapons on a simulated Soviet headquarters... It was a great confidence booster to have confirmation

[35] Robert Owen, 617 Squadron Historian, Operations Record Book, 617 Squadron, August 1968; extract provided: 4/4/19.
[36] "Doctrine and theory of Soviet anti-air defense", July 9 1958; translation of Russian language original document, Central Intelligence Agency, 5OX1-HUM, https://www.cia.gov/library/readingroom/document/cia-rdp81-01043r 002300240011-4

> that, if we ever had to do it for real, we had a realistic chance of success, provided it was at night.[37]

The 1963-64 switch to low level greatly increased V-Force war-fighting potential and, as verified by Roger Dunsford, this lingered, to some degree, far into the 1970s:

> … the Vulcan was an aircraft full of surprises. The Americans had a big shock when we flew that first Red Flag exercise at night … Despite their best efforts – using the latest Soviet fighter, SAM and anti-aircraft artillery technology and techniques – our aircraft came through unscathed! By the late 1970s we were no longer a viable day bombing force, but it was a very different story at night ... Even at the end of the 1970s, V-bombers at night posed a real threat to the Russians.[38]

ECM and other countermeasures

Air Marshal Sir Frederick Sowrey (2003) defined EW as "exploitation of the electromagnetic spectrum and the denial of its use to the enemy."[39] ECM included: deception (inserting false data), confusing (inserting redundant information, to delay and confuse) and overloading (an interference signal).[40] Operational V-Force ECM systems included the "Red Shrimp" barrage jammer (ARI 18076), the "Green Palm" communications jammer (ARI 18074) and the "Blue Diver" early warning radar jammer (ARI 18075).[41]

There were concerns about ECM serviceability in the event of war, including the significant unknowns surrounding the effects of EMP on airborne electronic systems. Vulcan Nav/Radar Roy Brocklebank recalls the lack of knowledge of EMP: "In 1966 we received a two or three-page request for anyone who might have knowledge of EMP. Given that the majority of V-Force aircrew were your typical five GCE men (and physics not being necessarily one of them), I don't think there was much response."[42]

V-Force ECM development proceeded in a stop-start manner. Air defence exercises in the 1950s demonstrated that V-bombers would need all the help they could get for successful high-level penetration. Yet, the first V-bombers had only rudimentary

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[37] Roger Dunsford, Vulcan Captain; amongst documents/text provided: 19/11/20.
[38] Ibid.
[39] Air Marshal Sir Frederick Sowrey, KCB, CBE, AFC, introduction to "Electronic warfare", RAF Historical Society, *Journal 28* (2003): 13.
[40] DEFE 58/90, "Defence penetration techniques", Strike Command Development Unit, Report No. 9/68 – Part 1: HQ STC Trial No. 549, Phase C, December 1968.
[41] Wing Commander "Jeff" Jefford, "EW in the early post-war years – Lincolns to Valiants", RAF Historical Society, *Journal 28* (2003): 58-69; Wing Commander Rod Powell, Vulcan AEO, "EW during the V-Force era", *Journal 28:* 70-85.
[42] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 12/8/19.

ECM, recalled Valiant Co-Pilot Dick Fuller: “We had no flares on board. The electronic jammers were pretty unsophisticated, but we had techniques for detecting fighters or missile launches. It was then a question of violent evasion – a variation of the ‘corkscrew’ of World War 2 vintage. This was a steep turn to the left, a vigorous pull-up, followed by a steep right turn.”[43] ECM installation accelerated in 1960; by end-1962 most Vulcan and Victor aircraft had the equipment. Until then, it was thought that Skybolt, launched outside defended airspace, would greatly reduce the need for ECM. Consequently, second generation ECM, including an advanced “comprehensive jammer”, was cancelled. Shortly afterwards, Skybolt itself was cancelled. Within two years, the V-Force went low level and this also appeared to reinforce the case for not proceeding with new generation ECM.[44]

“Window”, as first conceived in World War 2, had several potential roles. Aircraft could lay a Window corridor or screen, to mask other air activity, or it could be dispensed randomly to confuse ground radars. Trials and exercises showed disappointing results for Window in this context, but in the “chaff” role - deflecting threats to a specific aircraft - it proved more effective. Trial No. 512 (1966) tested low level use of chaff against a fire control radar. Bomber Command’s then Chief Research Officer, R.J. Monaghan, was heartened: “The results of this trial were very encouraging, in showing that the Window was remarkably effective in breaking lock, both in low level flight and in pop-up simulated attacks.” Trial No. 512 investigated the effects on AA No. 3 Mk. 7 (S-Band) tracking radar, when the target aircraft dispensed Type 26 Window at low level during level flight and in a simulated pop-up to 3,000 ft. The AA No. 3 Mk. 7 was considered to be a “near equivalent” to some Soviet AAA fire control radars. This trial took place at West Freugh Range; sorties were flown by a Vulcan. The report concluded: “The surprising result of this trial is the comparative ease with which unlocking was achieved at low level.”[45]

There could be conflict between Air Force and AEO priorities. Wing Commander Peter West listed the AEO’s three functions: traditional wireless communications, monitoring electrical systems and, thirdly, EW: “… largely overlooked, ignored, suppressed by the Air Force...” Yet, West regarded protecting his aircraft as the primary role: “I didn’t like flying in the Valiant. It was a lovely aircraft, well-built, but it

[43] Dick Fuller, Valiant Co-Pilot; amongst documents/text provided: 29/10/20.
[44] DEFE 58/90, “Defence penetration techniques”, Strike Command Development Unit Report No. 9/68 – Part 1: HQ STC Trial No. 549 Phase C, December 1968.
[45] AIR 14/4387, Bomber Command, Operational Research Branch, Memorandum No. 328, Trial No. 512, “Effectiveness of Window dispensed at low level against a fire control radar”, April 1966.

had no EW equipment of any note at all … The Vulcan had an excellent electronic suite which was becoming better all the time." The first level of protection was provided by the Nav/Plotter, rather than the AEO, as this was evasive routeing: "… we relied totally on good Intelligence and it still fills me with admiration how our Intelligence services … managed to provide all this information, including the sounds of the Soviet radar systems ... The first sound you are likely to hear … is just 'zu-zum' and, a minute's pause, 'zu-zum'. These were the big early warning radars … you picked them up at approximately twice the range that they picked them up." This was because of the bounce-back:

> Then you start hearing more interesting and more intense and urgent sounds... I remember one Soviet fighter of the 1960s that sounded as though it had got a Latin American beat. We nicknamed it "scan-can" and it went "bumpadum-bumpadum". When you heard that you were right to be a bit concerned, because it meant he was searching for you and he was close. But the thing you waited for was a steady note – "bizzzzzzzz" – that meant he had locked on and then you have really got to move.[46]

There were echoes of World War 2 and the interaction between gunner and Pilot: "The important thing is to give your Pilot commentary – let him know where the threat is coming from. His action then is to turn into the direction of the threat, exactly as it was done with gunners and Pilots in Lancasters, Halifaxes, Wellingtons, etc."[47]

Low level ECM

In a sense, the inadequacies of first generation V-bomber ECM were addressed at a stroke with the switch to low level. From that point on, what counted was electronic silence, giving little or no warning to SAM sites and gun positions as solitary attackers sped across the flat Russian terrain towards their targets. Crews would respond only to direct threats, as they arose. It took some time to make appropriate changes to high altitude ECM practices. In July 1963, with conversion to low level underway, Tom Kerr, then Bomber Command's Chief Research Officer, wrote a note on ECM and bomber defence. This was pessimistic about the value of Red Steer and Blue Saga warners, at high *and* low level:

> At low level, the main defence of the bomber is to remain low and undetected. In clear conditions, the 50% chance of sighting is probably about 10 miles range, varying from zero at about 15 miles to 100% at about five miles … there

[46] Peter West, Valiant/Vulcan AEO; "Defence through deterrence: British policy during the 1960s and 1970s", Witness Seminar, Institute of Contemporary British History and Defence Studies Department, King's College, London, September 10 2014.
[47] Ibid.

> is little a bomber can do once sighted and attacked visually. Under instrument conditions, the bomber flying 500 ft to 1,000 ft above ground level, there is only a small probability that the fighter will detect the bomber.[48]
>
> The bombers' warning equipments are unlikely to be of much value. Blue Saga will hear all the AI fighters within 30 to 40 miles and up to high altitudes, which are orientated correctly towards the bomber and on a direct line of sight. Red Steer will have over half of its extremely limited cover (a 45 deg. cone) unusable due to ground clutter, presenting an extremely difficult problem in detecting the fighter. Even when detected, the peculiarities of the display will make the assessment of its position extremely difficult. The greatest safety of the bomber will be obtained by descending to a lower altitude if possible, manoeuvring, etc, being only of limited value.[49]

Vulcan AEO Peter West was operational during the low level transition:

> When we went low level, we still needed the radar warning receiver to pick up the AAA and portable missile threats, together with the fighters with low level capability. Our big problem was the multi-barrelled 23 mm gun. It could tear an aircraft to bits… as the Americans found out in Vietnam... It was part of my job to ensure we never got into its cone of fire.[50]

AEO Julian Grenfell continued to apply his EW knowledge, coming up with the idea of a C-Band forward-looking antenna, to counter acquisition radars. He proposed a modification to Red Shrimp: "This took the pulse from FAN SONG and shifted it, in effect presenting FAN SONG with a false range." It was not taken up. Crews were not briefed on new Soviet SAM systems, as there were no EW systems to combat them: "The SA-8 had capability down to 80 ft and the only answer was jamming in phase. Yet there was no V-Force capability against semi-active and active pulse Doppler. Remarkably, we'd had the answer to this years before, in the so-called 'Comprehensive Jammer', but that was cancelled in 1960."[51]

Short timescales and a determination to avoid expenditure on the V-Force during its final years on the strategic frontline contributed to lack of interest in ECM at the top, despite the fact that V-bombers had no defensive armament. Time and budget pressures, set against the huge investment made in Soviet air defences, generated

[48] AIR 14/3898, "The use of warning devices (Red Steer and Blue Saga) during attacks by fighter aircraft on bomber aircraft flying at high and low level", minute, Bomber Command Chief Research Officer T.H. Kerr, July 4 1963.
[49] Ibid.
[50] Peter West, Valiant/Vulcan AEO; interviewed: 30/4/19.
[51] Julian Grenfell, Vulcan AEO; interviewed: 10/12/18.

pessimistic attitudes, even very early on. In May 1960, for example, Bomber Command's then Acting Chief Research Officer wrote in blunt terms:

> The warning systems provided for bomber aircraft as part of the ECM fit and the proposed alterations in the future do not represent a satisfactory solution to the real problem of providing a bomber with adequate warning of enemy fighters or missiles. The great weakness with our present set-up is the problem of interpretation, which becomes critical if one talks about missiles attacking bombers. I cannot believe that suitable equipment which will solve this "defence of the bomber problem" could be made available during the next four to five years and, therefore, I suppose we must begin to forget the potential value of such equipments, which would be invaluable today but of limited value after 1965.[52]

This bleak summary formed part of the background to the long squeeze on V-Force equipment upgrades. By 1963-64, it was argued that ECM upgrades had no place in low level nuclear strike, with Polaris just a few years away. Aircrew lived with the situation and most AEOs were phlegmatic. Nothing much changed. AEO Dave Beane was flying operationally two years *after* the Polaris handover: "As AEO I had the usual mix of active and passive ECM systems. They were as up-to-date as they could be, given that ECM – by their very nature – are always a step behind the threat they are supposed to counter."[53] AEO Barry Masefield, operational during an even later period, had a different outlook: "… there had been no recent upgrade when I arrived on the V-Force at the end of the 1970s. The chance of a successful retaliatory strike in Vulcans had been much diminished by that time. We had fallen further and further behind."[54]

Vulcan Flight Commander Roger Dunsford noted that the Americans, relatively free of funding pressures, took a different approach:

> Eventually, there came a time when some Americans saw the V-bombers as a spent force – an obsolete weapons platform. Yet, there remained a feeling of respect for the British ability to make a great deal out of very limited resources. The US had thrown money at the B.52 – the same generation as the Vulcan – by installing the latest EW suites and arming it with cruise missiles… in order to make it a viable weapons platform… we could not afford to do the same with the Vulcan; we were always looking for innovative ways to improve our capability by constantly adapting the equipment, procedures and training on the frontline squadrons.[55]

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[52] AIR 14/3898, BC/S.554/Res., note from R. Bruce, Acting Chief Research Officer, Bomber Command, May 6 1960.
[53] Dave Beane, Victor/Vulcan AEO; amongst documents/text provided: 27/10/20.
[54] Barry Masefield, Vulcan AEO, 617 Squadron, RAF Scampton; interviewed: 27/2/18.
[55] Roger Dunsford, Vulcan Captain; amongst documents/text provided: 19/11/20.

Not all V-bomber AEOs kept quiet about inadequate ECM. Those willing to speak out included Hugh Prior:

> There were Green Palm VHF and UHF jammers and Red Shrimp, to jam SA-2 radars, but SA-2 was the least of our worries. The real threat came from SA-3, SA-6 and SA-7 (a hand-held weapon) and the ZSU gun. We had nothing to counter these weapons … I got annoyed when I found that many AEOs appeared to be satisfied with this state of affairs … To be fair, I also remember that some aircraft then had equipment to jam behind and in front, to interfere with SA-3 and gun radars and there was general agreement that our infra-red decoys (IRDs) and chaff were good.[56]

When the V-bombers went low level, they carried Type 22 Window (X-Band, against fighters) and Type 150 Delayed Action Window (DAW). According to Nav/Radar Roy Brocklebank, the main purpose of Type 150 DAW "was to sow confusion during the high level recovery phase". [57]

DAW was parachute-deployed and burst well behind the aircraft. There were IRDs, fired in bursts of four at high level and two at low level. There was also Rapid-Blooming Window (RBW X-Band (I-Band)) chaff:

> Type 22 was dropped to the formula 5-10-2, if I recall correctly. This was five bundles per second for 10 seconds, at two-second intervals. At this rate, we experienced "stripper runaways". The stripper had to open the cardboard packet, to enable the Window to bloom. Failure was reduced at 3-10-2.[58]

Hugh Prior, later EW Officer at Waddington, added: "Could we have flown a successful retaliatory strike? In the 1970s, crossing the coastal defence belt would have been like threading your way through a string of pearls. If you were ultra-low and lucky, it could have been done. One progressive development was more discrimination from equipment scanning for threats."[59]

Some things, however, didn't change. John Reeve, a Vulcan Pilot, had Riga amongst his targets: "Our ECM aerials remained positioned for high level attacks. They were

[56] Hugh Prior, Vulcan AEO, 44 (Rhodesia) Squadron, RAF Waddington; interviewed: 30/5/18.
[57] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 18/3/21.
[58] Ibid.
[59] Hugh Prior, Vulcan AEO; interviewed: 30/5/18.

still in the wrong place when the Vulcan left service in 1982. There always seemed to be a 'What's the point?' attitude to spending money on the V-bombers."[60]

Renewed interest in ECM

It would be wrong to suggest that absolutely nothing was done to upgrade ECM, but V-Force expenditures were subject to strict control during the 1960s. ECM took a back seat, at least until the 1966 Defence White Paper and a change in planning emphasis, from general war to limited war operations against an enemy with defensive weapon systems of the same vintage as the Vulcan's ECM. This eventually led to a trial of ECM use and effectiveness at low level, for that part of the Vulcan force (i.e. freefall squadrons) with a conventional low level commitment. This study was for war in a non-European context, against an enemy armed with C-Band or S-Band SA-2s, but unlikely to have capability against aircraft flying below 1,000 ft or during a brief pop-up. By night or IMC, the enemy defence threat consisted of interceptors (FISHBED variants) fitted with SPIN SCAN AI radar and armed with ATOLL IR missiles and/or guns. Radar-controlled AAA guns were assumed present. The day/VMC threat also included day fighters (FRESCO, FARMER, FISHBED) with gun-ranging radars (SCAN FIX and HIGH FIX), armed with guns or IR missiles (ATOLL), plus visually sighted AAA guns and small arms fire.[61]

"Phase C" trials were designed to determine the best way of evading interception from the ground or from the air. Tactics were required to meet three situations: attack by AI-equipped or day fighters with missiles and/or guns at 500 ft over land and sea; when flying at 500 ft, AEO recognition of illumination by radars; and radar tracking by Air Defence Artillery (ADA) fire control radars during the attack phase. The risk of use of the Vulcan force in a non-European theatre raised political questions, given the small size of the force, high unit cost, the inability to replace aircraft and the need to avoid situations where the risk includes loss from, for example, small arms fire. Safety of the aircraft took precedence over weapons delivery.[62]

By late 1968, the latest penetration aids fitted to, or ordered for, the Vulcan freefall force included:

[60] John Reeve, Vulcan Co-Pilot, 27 Squadron, RAF Waddington; Captain, IX Squadron, RAF Akrotiri; interviewed: 29/5/18.
[61] DEFE 58/90, "Defence penetration techniques", Strike Command Development Unit, Report No. 9/68 – Part 1: HQ STC Trial No. 549 Phase C, Annex C, December 1968.
[62] Ibid, main report.

- ARI 18146: an active jammer with several different modes (including a receive facility, providing X-Band coverage to the rear).
- ARI 5952 (Red Steer Mk. 2): a tail-warner differing from the Mk.1 mainly in its scan pattern (over which the operator had an element of control).
- Cartridge Discharger No. 3 Mk. 1: a system to explosively discharge decoys in pre-set quantities and at pre-set rates.
- ARI 5959: terrain-following radar.[63]

In July 1966 AEO Martin Anscombe completed a five-year double tour on Vulcans. The RAF had plans to further harness his electronics expertise: "I was posted to a Signals Command station at RAF Watton in October 1966 where a new EW flying unit, No. 360 (RN/RAF) Squadron, was being formed to provide an airborne EW training platform for all three services, and which was to be crewed and serviced by Air Force and naval personnel on a 2:1 basis." Eventually, 360 Squadron was equipped with the Canberra T.17, a fully refurbished B.2 with the entire bomb-bay filled with jammers. Some devices were designed to search for fighters, whilst others were powerful blast jammers directed against ground radars. There were devices capable of locking onto and jamming AI fighter radars. "Our role was to train all aircrew and other system users who would expect to operate in a hostile electronic environment and training included evasive tactics using chaff …"[64]

Wing Commander Rod Powell, a Vulcan AEO, arrived at Scampton in 1966, joining 83 Squadron flying Blue Steel-armed Vulcan B.2s. Writing in 2003, Powell commented:

> On paper the Vulcan had an impressive defensive suite comprising powerful jammers, a radar warning receiver, a tail-warning radar, infrared flares and oodles of chaff. This kit provided a reasonable degree of situational awareness, even by today's standards, and the crew could therefore take the necessary action to avoid or evade the ground or air defences. Or could it? We will never know what the survivability rate of the V-Force would have been, but my guess is that many of the aircraft would have been shot down before they reached their missile release point or, in the case of the freefallers, the target, because, to be honest, the EW suite we had at the time was just not good enough. The change to low level operations in 1963 should have been accompanied by a change in EW tactics and a re-appraisal of the system's capabilities. This simply did not happen, at least, not in any meaningful way.[65]

[63] Ibid, Annex B.
[64] Martin Anscombe, Vulcan AEO; interviewed: 28/2/18.
[65] Rod Powell, Vulcan AEO, "EW during the V-Force era", RAF Historical Society, *Journal 28* (2003): 70-85.

Powell felt that AEOs "should have been far more assertive" in pressing for improvements to enhance survivability. It was obvious that single low level penetrators should be electronically silent – responding only to direct threats – but it seems the pace of change was very slow. Powell did acknowledge some late ECM improvements: "To be fair, despite what I perceive to have been a general lack of application, some effort was made to provide some aircraft with a more effective jamming capability."[66] This involved the fitting of the X-band jammer.

Beyond the late 1960s ECM upgrade with operations in a non-European limited conventional war in mind, the parsimonious attitude continued. In April 1970, less than a year after the Polaris handover, the VCAS, Air Marshal Sir Peter Fletcher, wrote to Strike Command AOC-in-C Sir Denis Spotswood, confirming that there would be no further updating of Vulcan ECM, to provide an active capability. There was no stomach for a fight for funding: "Although the operational arguments are strong, I have… reluctantly come to the conclusion that we should not press ahead with these proposals at this stage. The cost involved is very considerable – some £12.36 million – and we could not be confident of securing agreement to go ahead. The effect of an adverse decision could well be to put the whole future of the Vulcan force at risk."[67]

The CAS agreed with Fletcher's decision, "with reluctance". The worry was "Pandora's Box" - an attempt to proceed would attract the attention of those who would argue that it would be wrong to put expensive equipment into ageing aircraft; it might even prompt retirement of the V-bombers. The VCAS took the view that, even without modern ECM, Vulcans could still be used low level at night "for the specific purpose of a late nuclear strike …" He made no mention of what Vulcans and crews should do in the meantime, should war begin in the morning.

Penny-pinchers held the reins and operational impacts in a hot war might have been catastrophic. One example was chaff, carried in large quantities by the Vulcan and held in "Window Boxes" in the wing, two per side, just aft of the main undercarriage legs, as described by Rod Powell: "In all, we had 4,000 packets of chaff, each packet being about nine inches long, three inches wide and half-an-inch thick. It was pre-cut

[66] Ibid.
[67] AIR 8/2572, letter from Air Marshal Sir Peter Fletcher, VCAS, to Air Chief Marshal Sir Denis Spotswood, AOC-in-C Strike Command, April 13 1970.

to various lengths, giving us wideband frequency coverage."[68] Air Vice-Marshal Nigel Baldwin (2003) recalled his 1978 visit to Nellis AFB, to participate in the first night Red Flag combat exercise:

> We were permitted the use of all our ECM and could, if necessary, use all of our chaff. The first time the AEOs tried it, the dispensers jammed after having discharged only 20% or so of their contents. On investigation, it was discovered from the date stamps on the remaining packages that they were 15 or more years old! The contents were so compressed that they defeated the mechanism …[69]

In the interests of balance, however, Roy Brocklebank points out that RBW and IRD were "state of the art" and the X-Band jammer eventually arrived.[70]

In conclusion, British air defence exercises exposed the vulnerability of V-bombers attempting high altitude attacks in daylight. Studies and trials revealed the advantages of low level strike, with reduced exposures to SAMs and fighters. The oral evidence suggests that briefed minimum altitudes were often ignored by determined Captains enjoying the confidence of their crews. The important 1971 Air Force Department paper sets out a highly favourable view of the ability of ultra low-flying Vulcans to penetrate below the envelope of SAM and fighter engagement, yet, in all probability, this optimistic view was supported by the likely severe degradation of Soviet defences in a mass strike by American ICBMs. It is evident that more V-bombers would survive to the point of weapon release if the war sortie was flown at night and/or in IMC. There is also compelling evidence from the strong performance of Vulcans in US Red Flag battle practice in the 1970s. Equally, there are missed opportunities in the area of ECM, including cancellation of the "comprehensive jammer" and a failure to undertake a sweeping review of ECM outfit and tactics to accompany the switch to low level.

[68] Rod Powell, Vulcan AEO, "EW during the V-Force era", RAF Historical Society, *Journal 28* (2003): 70-85.
[69] Air Vice-Marshal Nigel Baldwin, discussion period, "Electronic Warfare," RAF Historical Society, *Journal 28* (2003): 104-110.
[70] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 21/4/20.

– 10 –

VULNERABILITIES IN THE AIR: ATTACKING THE TARGETS

This final chapter on V-bomber vulnerabilities in the air considers the attack phase. Various weapon delivery profiles are reviewed, including low level laydown. ECM issues considered include protective jamming and the ability to overcome enemy jamming of an attacker's NBS. The V-bomber's ability to withstand blast and direct radiation from the detonation of weapons is examined and escape manoeuvres to be flown following release are described.

Through the Baltic defences

During the wait for Polaris, Britain became increasingly reliant on the ability of V-Force crews to apply extreme combat tactics to overcome, to some degree, the inadequacies of aircraft and weapons. Given their high level of training and commitment, it is likely that, had a war sortie been flown, a few (perhaps a few more in a night operation) would have succeeded in putting weapons on targets. Long odds did not disturb the crews; they adopted an aura of fatalism. In this atmosphere, it is easier to understand why "making a fuss" about inappropriate ECM or the poor prospects of surviving a laydown attack seemed hardly worth the trouble. Deterrence would hold and the war sortie would never be flown.

Should this faith in commonsense prove ill-placed, V-bombers fortunate enough to survive a pre-emptive strike would have crossed the North Sea and, if authorised, would have attempted to penetrate the Soviet coastal defence belt, area defences and, finally, in the case of the free-fallers, point defences surrounding targets. Assuming the go-ahead, they would have crossed Norway, to begin their descent over Sweden for low level penetration. Vulcan Nav/Radar Jim Walker expected "Positive Release" at, or very shortly after, scramble - otherwise "the whole system was flawed … EMP would have surely blanked out radio transmissions."[1]

Andrew Brookes (2015) described how the bombers would have crossed the Baltic coast through three narrow "gates" in the high level era. The plan was to penetrate

[1] Jim Walker, Vulcan Nav/Radar; interviewed: 26/3/19.

Soviet airspace in loose cells of six, flying at speeds of up to Mach 0.93, at heights exceeding 50,000 ft. Reaching the targets would have required evasive routeing and the use of ECM.[2]

Entering Soviet airspace through three gates was intended to saturate local defences (although, in reality, V-Force survivors may have lacked the numbers to achieve this effect). Roy Brocklebank, Wing Targeting Officer for Waddington's 24 Vulcans, said the gates might be "no more than about three miles wide. In the low level era, the gate concept was abandoned. Single aircraft would have crossed the coastal defence belt at ultra-low level. Low level penetration meant higher fuel consumption: "The deepest penetration targets were up to 550 miles, maybe a little more ... Some would require, for very deep penetration, Vulcan aircraft with bomb-bay fuel tanks. These could give up to 25% more fuel than the standard fuel fit, but only once we got the WE.177 weapon."[3] This refers to WE.177's small size.

Some aircrew, including 44 (Rhodesia) Squadron's Jim Walker, had concerns about coming in over Sweden: "Would the Swedes shoot us down? Had anyone told them we were going to do this? I understood they had a very effective Air Force."[4] Apparently, the Swedes were told. Richard Moore (2010) explains: "Swedish air defence was evidently not considered a threat to the V-Force. Despite its official neutrality, the Swedish Government had made a series of secret arrangements to facilitate British and US use of Swedish airspace in wartime, including for the purposes of nuclear attack."[5] Roy Brocklebank remembers a friend's story - a Swede had told him: "We were neutral, but we knew who we were neutral against."

Some V-bombers and other British strike aircraft (including nuclear-capable Canberras and Buccaneers), in pursuing their missions, would destroy coastal defence belt targets - opening the way for the MBF and, later, waves of US-based SAC bombers. Roy Brocklebank notes that only a proportion of SAC aircraft were routed over the Pole:

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[2] Wing Commander Andrew Brookes, *RAF V-Force: Operations Manual* (Yeovil (UK): Haynes Publishing, 2015), 119-123.
[3] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; "Defence through deterrence", Witness Seminar, Institute of Contemporary British History and Defence Studies Department, King's College, London, September 10 2014.
[4] Jim Walker, Vulcan Nav/Radar; interviewed: 26/3/19.
[5] Richard Moore, *Nuclear illusion, nuclear reality*, 207, 293, citing Robert Dalsjö, *Lifeline lost: the rise and fall of "neutral" Sweden's secret reserve option of wartime help from the West* (2006), 164-5.

> If you run out a line from Elgin AFB to Moscow, you enter the USSR exactly on the RAF penetration route. Barksdale is not far from Elgin; Loring, much further north, follows the same route... Fairchild, in Washington State, would also cross Greenland and a little further north in Norway but still enters the USSR through the Baltic States. However, shift their targets to Kola or Novaya Zemla and they start to use Polar routes.[6]

Attack profiles

V-Force crews trained in various weapon delivery formats, or "attack profiles". The original, high level freefall attack was Type 2; this became 2A, an evasive attack run, after the loss of Gary Powers' U.2. Roy Brocklebank describes 2A: "It began some 40 miles from target: the bomber pulled 1.5G through 45 deg., levelled wings for 15 seconds before turning 90 deg. in the opposite direction. Wings were levelled for 30 seconds before the evasive manoeuvre was repeated. The following steady leg was for 15 seconds, before the bomber rolled onto the attack heading around 15 miles out from the target." This profile was designed to defeat SA-2, which required at least 60 seconds' uninterrupted lock. Attack profiles changed when the V-Force went low level.[7]

The first British low level strike bombers were SACEUR-assigned Valiants carrying American "E" weapons, including "Big E", the Mk.43 laydown bomb. Dick Fuller was a Valiant Co-Pilot with 49 Squadron during the 1959-63 period. Whilst at Marham, crews trained to deliver weapons, including the American laydown bomb, in the "hi-lo-hi" operational profile: "We would go out at height then drop down to around 300 ft on crossing into enemy territory." On release they would put the aircraft into a very steep turn, in an effort to escape the shockwave:

> There was also the flash to worry about. When we were blacked out by screens, the Captain and Co-Pilot had a sort of "letterbox" to look through. Flying visually at 300 ft by peering through a letterbox leaves the probability of "clobber" rather high. If the Pilot was blinded by the flash, the Co-pilot had to be ready to take over. I suppose most of us thought that war would be a one-way trip for the Valiants.[8]

Vulcan and Victor freefall bombers flew a hi-lo-hi mission profile from 1963-64 onwards, but their Yellow Sun 2 bombs required a "pop-up" to 11,000 ft for successful release, so forcing the aircraft to enter SA-2's engagement zone. They trained for 2E and 2H attacks. The 2E required a rapid pop-up climb to 11,000 ft, with the aircraft

[6] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter re: "Plan A": 9/8/18.
[7] Ibid; email: 4/6/19.
[8] Dick Fuller, Valiant Co-Pilot; amongst documents/text provided: 29/10/20.

steadying for weapon release in level flight for three miles. The 2H was a release in the climb. The average time from exposure to enemy SAMs to weapon release was about two minutes, but an alerted missile crew could achieve a successful engagement in 112 seconds. Roy Brocklebank described 2H, designed to overcome this:

> This was a precisely calculated approach to a pull-up, offset for wind effect - a timed rotation to the designated climb angle and release in the climb at 10,500 ft. This reduced exposure to enemy missile systems to the absolute minimum … the attack would begin about 30 miles out, when the Initial Point (IP) would be detectable on radar. At the IP, the aircraft would settle at its attack speed of 350kts, aiming to get to the pop-up point 18,350 yards short of the target and 103 seconds before the desired Time On Target. At the "pop", the Nav/Plotter would call the pop and count down five seconds. The Pilot would rotate the aircraft smoothly into a 15 deg. climb and fly a fixed heading until passing 10,500 ft and climbing at about 10,000 ft per minute. The Nav/Radar and Co-Pilot would both press their bomb release buttons. This would be about 85 seconds after the pop and two miles from the target. It was estimated that the weapon would explode 9-17 seconds before the SA-2 could hit the bomber.[9]

> Immediately after bomb release, the Co-Pilot would close the bomb-doors, the Captain would bank the aircraft, pulling a 1.8G turn through 140 deg. before levelling the wings and continuing the climb. The aircraft was now presenting its minimum profile to the target and the resultant light, heat and shockwaves. Crews were told that the blast overpressure … would not exceed 0.98 pounds per square inch ... aircraft were expected to suffer structural damage with overpressures of one pound or more! After the escape turn, the aircraft would continue climbing and weaving to avoid SAMs, whilst maintaining a heading to the recovery airfield. Climbing and turning, we would get to about 48,000 ft before we had to moderate the turns and continue climbing for height. It would take about 120 miles to reach 50,000 to 55,000 ft.[10]

The Valiant's principal attack profile had been 2F – a low altitude release of the American laydown bomb in level flight at about 320 kts and 500 ft. Roy Brocklebank said this was regarded as the safest, after a Blue Steel attack: "The aircraft would remain below the SAM cover but would be vulnerable to air defence artillery." Blue Steel crews did not have to enter the inner target area, provided their weapon "agreed" to launch in the powered condition:

> The Blue Steel missile could be fired at low level about 30 miles from the target … The delivery aircraft would have safe separation from its own weapon's effects and had no need to penetrate the target defence zone. If the missile

[9] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer, "How did Bomber Command prepare for war?", article for *Flypast (*October 17 2008), based on a lecture to the Royal Institute of Navigation's History of Air Navigation Group, Tangmere.
[10] Ibid.

guidance or propulsion system failed, however, the crew would have to use the same delivery profile as for Yellow Sun.[11]

An attacking V-bomber could expect attempts to jam the bombing system. Bomber Command tested the effects of a single H_2S jammer over the January-April 1962 period. There were 269 bombing runs on jamming and on some 96% of occasions "fairly intense" jamming was generated on H_2S displays. However, by the third attack, the average Nav/Radar "had ceased to be troubled by the H_2S jamming from a single jammer and the bombing error thereafter was not markedly different from normal bombing runs." The main reason was the countermeasure effect of the NBS long-range offset facility.[12] At the same time, in a hot war sortie, each bomber would make *only one attack*.

During Autumn 1962 a Bomber Command report on the bombing of targets protected by multiple H_2S jammers concluded that three ground jammers "do not destroy all the information content of the H_2S display of an attacking bomber …" It estimated that at least five jammers were required to provide complete jamming around a target. "Such jamming conditions would impose a very great problem to the Nav/Radar and the bombing accuracy would certainly suffer in consequence." The ORB took refuge in a favourable assumption: "Since the full protection of a target by ground H_2S jammers is a very expensive proposition, it is not unreasonable to assume that, in operations, jamming much more severe than that experienced in the trial with three jammers is unlikely."[13] However, was the provision of two extra jammers prohibitively expensive, in terms of protecting a large city? Equally, jamming capability would, in all probability, have been destroyed or severely degraded in an initial missile strike.

The V-bombers' own jammers were tested for effectiveness in protecting an aircraft during a low level pop-up for freefall Yellow Sun 2 (or unpowered Blue Steel) delivery. Exercise "Blank Stare II" examined Red Shrimp's ability to shield a solitary bomber making a pop-up attack from SA-2 S-Band radar. The trial, flown during April 1963, sought to identify the optimum arrangement of Red Shrimp transmitters to counter simulated SA-2 batteries. Sorties were flown by Vulcan 1A and Victor 1A aircraft operating from Seymour Johnson AFB, North Carolina, around 200 miles from the

[11] Ibid.
[12] AIR 14/4320, Bomber Command, Operational Research Branch, Memorandum No. 251, "The use of H_2S jammers in Bomber Command, January-April 1962", June 1962.
[13] AIR 14/4325, Bomber Command, Operational Research Branch, Memorandum No. 256, "The bombing of targets protected by multiple H_2S jammers", October 1962.

test radar at Chesapeake Bay. The results were surprising: the aircraft could jam effectively during the pop-up (in contrast to theoretical studies suggesting negligible effects). In the initial low level/climb tests, from 1,500 ft (lowest altitude permitted) to 12,000 ft, "successful self-screening during the climb was achieved on 16 out of 22 occasions … A much superior self-screening capability was evident during climbs in front of the radar than in those behind the radar. However, in the latter climbs … the effectiveness of the jamming from that direction was greater than would have been expected." Use of Window during the climb offered no advantage and "could be of direct assistance to the radar operator in determining the range of the aircraft."[14]

John Weller, a Vulcan Nav/Radar on IX Squadron, spent much time practicing attack profiles, beginning with the high altitude Type 2 and the evasive 2A variant: "The 2B was flown through jamming. We practiced this with Radar Bomb Scoring Units. Some had jammers that picked up our signal, amplified it and re-transmitted it. The challenge was to find the 'offsets' beyond the jamming. The 2C profile was jammed/evasion, but we never flew that." Weller moved on to the 2E pop-up and the 2H pull-up variant for releasing Yellow Sun 2: "The 2H manoeuvre was thought up at Boscombe Down. It came in during March 1966."[15]

System malfunction was always possible during the attack and crews trained to overcome such problems. Vic Bussereau, a Vulcan Nav/Radar, recalled that, normally, the radar-generated markers were placed over the target or the offset in the stabilised mode, with the markers in the centre of the screen. If the markers didn't come up, the attack was made by pre-referenced chinograph marks on the screen. The "electronic centre" of the screen could be manipulated, depending on which way the target was approached. If it proved impossible to get a stabilised mode, a plastic quadrant gave the Nav/Radar an allowance for drift.[16]

Each crew's Time On Target gave three minutes' tolerance on each side. This was designed to provide minimum separation between bursts during multiple strikes on a large target. Waddington Wing Targeting Officer Roy Brocklebank had concerns:

> Clearly, having near simultaneous TOT would, if each aircraft got through, have catastrophic results in fratricide … I took this up with Norman Howard, who was

[14] AIR 14/4343, Bomber Command, Operational Research Branch, Memorandum No. 274, "Exercise Blank Stare II, Trial No. 457", August 1963.
[15] John Weller, Vulcan Nav/Radar; interviewed: 1/8/18.
[16] Vic Bussereau, Vulcan Nav/Radar, 35 Squadron, RAF Cottesmore/RAF Akrotiri; 50 Squadron, RAF Waddington; interviewed: 6/6/18.

> Ops. 1A at Bomber Command. He was the one who drew up the plans. He said he was aware of this and was trying to change the TOTs to improve the chances of actually getting bombs on targets. Obviously, against this was the advantage of saturating the target defences and that would be reduced by dissipating the concentration.[17]

In reality, the large-scale casualties on and near V-bomber bases, resulting from a Soviet missile strike, would almost certainly have removed this theoretical problem near and over the targets. There would have been no concentration, with the possible (and significant) exceptions of Moscow and Leningrad.

Blue Steel crews had trained hard with their temperamental weapons, designed for high altitude launch. Then the decision to go low level was announced. In late 1963 Victor Captain Jeremy Mudford and crew collected the first B.2 modified for low-level launch:

> We had been expecting them. We had practiced missile launches at high level and, suddenly, we were preparing for launches at 250 ft. We took it in our stride … There was a round-Britain route with low level runs. There was a let-down over Dartmoor and a 250 ft run over the Bristol Channel and across Wales. We then headed up to Scotland, for a return along the east coast. However, low-flying time was limited, due to its adverse impact on airframe fatigue life. [18]

Nevertheless, time was found for the Mudford crew to fly at 300 kts at 250 ft over RAF Wittering on a Press Day introducing low-level Blue Steel aircraft.

Eventually, the pop-up era for freefall squadrons ended with the arrival of WE.177B laydown weapons in late 1966/early 1967. Vulcan Nav/Plotter James Vinales' crew planned to drop it from about 300 ft, flying at around 360 kts: "We would be about six miles away when hit by the shockwave. We were warned that the shockwave could put the aircraft into a nose-down attitude, so the Pilots were ready to pull up after release."[19]

It may have been freefall, but WE.177B was described by Mike Fazackerley as a complex and extremely sophisticated weapon:

> …there were no less than 882 different combinations of delivery method and fuzing in the A store and 435 in the B store. The minimum height for the Vulcan

[17] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; letter: 16/8/18.
[18] Jeremy Mudford, Victor Captain; interviewed: 8/2/18.
[19] James Vinales, Vulcan Nav/Plotter, 44 (Rhodesia) Squadron, 101 Squadron, 50 Squadron, RAF Waddington; interviewed: 24/7/19.

> to release a WE.177B in ballistic mode was 25,000 ft and, for laydown, the minimum delivery height was 60 ft and the maximum 1,000 ft. The aim in the laydown mode was for the weapon to slap-down tail-first, so that the tail unit could absorb a lot of the impact.[20]

Weapons on targets

V-Force capability and credibility became increasingly dependent on extreme combat tactics and the expertise and courage of crews. Reliance on hardware (aircraft and equipment) declined as new weapon systems were cancelled, so requiring crews to continue to plan to make low level deep penetrations into increasingly hostile airspace. Blue Steel Mk. 1, in its powered state, represented a limited advance in capability, but many carrier aircraft would still have to brave coastal and area defences, launching on the outer fringe of point defences around the target. Victor Nav/Radar Norman Bonnor described how Blue Steel Mk. 2 and the Blue Streak ballistic missile were cancelled in favour of Blue Steel Mk. 1 and the promise of Skybolt, which had a range exceeding that of Blue Steel Mk. 2. When Skybolt was cancelled, "this left the squadrons with Blue Steel Mk. 1 and freefall weapons, relying on the skill of crews operating high altitude bombers at extremely low level." A great deal of faith was placed in the ability of crews to get the best from what they had. "We always assessed our skill levels as far exceeding that of the majority of SAC crews. This was demonstrated in the SAC and Bomber Command bombing competition results."[21]

Freefall crews were expected to close with and directly overfly their targets. Could aircraft dropping WE.177B survive a laydown attack? Mike Fazackerley suggested that it could be done:

> The Weapons Development Committee set up a Weapons Effects Study Group in 1966, with AWRE in the lead, to conduct studies and trials ... Broadly, it concluded that the primary risks, depending on the nature and size of detonations, were blast, direct radiation effects and EMP. Thermal effects, flash blindness and fallout were judged to be of lesser concern. The fatal zone for aircraft originally designed for high level operations (ie. the Vulcan) was determined to be a blast overpressure greater than 4 psi or a direct radiation dose of 150 Rad. Damage could be expected above 1.5 psi blast pressure but not sufficient to prevent the mission. For yields below about 30KT radiation was the predominate risk factor. For larger weapons, blast was the predominate risk factor… the lethal (4 psi) zone for the Vulcan from a 450KT detonation (eg. WE177B) was calculated at 4.3km or 2.3NM. The Vulcan's one-time-only speed over the target was 415kts or 1NM every 8.7 seconds. So, it follows that, in

[20] Mike Fazackerley, nuclear weapons historian; notes: 16/11/20; 20/2/21.
[21] Norman Bonnor, Victor Nav/Radar; amongst documents/text provided: 1/11/20.

> order to ensure survival, there needed to be a minimum of 20 seconds between release and detonation. To ensure no risk of some structural damage would require about twice that. Actually, the distance/times were probably lower because the studies were based on a worst case of an aircraft height of 200 ft and a low airburst, which gives a greater blast overpressure because of reflected blast wave. A groundburst (eg. WE177B) and/or the opportunity to climb higher would have both reduced the overpressure significantly … it would seem that the claimed 32 seconds would certainly have enabled survival and quite possibly have placed the aircraft beyond the risk of damage. [22]

Roy Brocklebank gave his views on 2F laydown attack:

> … our post-attack manoeuvre was not declared an escape manoeuvre but undoubtedly was. It was to maintain straight and level flight for 10 miles. This would have ensured the tail was on the target. It would also have the effect of reducing the radar cross-section with respect to AAA and short-range SAMs … I calculated that the aircraft would be at about 5.5 miles from the target by the time the blast reached it and the blast decay would be below 1.5 psi. I don't believe my crew would have planned to fly higher post-release, though that might have been prudent. At the 10-mile point, most recovery profiles required a 180 deg. turn and a parallel track. This track would have been about six miles displaced from the attack track. Abeam the target, the aircraft was to climb to its maximum altitude, activating the jammers and flying SAM evasive routeing … The advantage of the delayed climb was its proximity to destroyed defences on the ground. Once above 30,000 ft, the only weapon, until the SA-5, that could catch them was the SA-2. At this stage of the war I would be surprised if there were many air defence fighters operable.[23]

Another explanation for the return to the target would be to act as a decoy, with the degraded defences unable to distinguish between a bomber without bomb and a bomber still with weapon and on its attack run.

Roy Brocklebank is adamant that Vulcan crews were told that the time between drop and detonation was 32 seconds but, according to Mike Fazackerley, the weapon did not have a 32-second detonation time available. However, WE.177 did have a 32-second *arming* time available on the Ground Control Unit: "…evidence points to the fact that the timer that was initiated on weapon release and that first armed the weapon and then detonated it was pre-set to a detonation time of 28 seconds in laydown mode, as long as the requisite safety breaks had been closed. The primary reason for minimising the time to detonation with laydown was because of concerns regarding weapon vulnerability whilst on the ground .... the aim was to balance aircraft/crew survivability with minimum weapon time on the ground." [24]

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[22] Mike Fazackerley, nuclear weapons historian; email: 10/8/19, citing AIR 2/18150, WDC(NC).
[23] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 10/8/19.
[24] Mike Fazackerley, nuclear weapons historian; emails: 29/7/19, 15/11/20.

The escape period was from release to detonation, plus the time required for the first shockwave to catch up with the aircraft. Roy Brocklebank did the sums: "… assuming a release speed of 415 kts and 32 seconds from release to bang, the aircraft would have travelled about 7,500 yards, or 3.7NM. The shockwave speed is around 1,000 yards per second. This gives an overtake speed of 766 yards per second … about 10 seconds. Our aircraft would travel a further 2,300 yards in that time, a total of about 10,000 yards – or about 4.93 miles." Allowing for the potential decay of shockwave speed, the total escape distance is "nearer the 5.5NM I calculated 50 years ago." Counterforce targets were often airfields largely free of obstructions but, in the case of countervalue targets (or counterforce targets within greater urban areas), the shockwave would be attenuated more quickly by buildings, so allowing additional time to escape.[25]

The credibility of the British deterrent threat hinged on the ability of a few V-bombers to get through. A successful V-bomber attack would have required luck and exceptional performance in combat: intelligent evasive routeing, prompt and effective countermeasures against direct threats, pinpoint navigation and timely arrival at the target/launch point, followed by faultless weapon release. There is a probability that, in war, a handful of surviving V-bombers would have put weapons on targets – even in a unilateral attack. *The challenge for the Soviets would be to kill every single penetrator prior to weapon release*.

When Polaris assumed the strategic nuclear lead, the British deterrent threat no longer relied on the survival of a handful of subsonic bombers. Vulcan Captain Roger Dunsford argues that the V-Force's significance continued for another decade:

> The Soviet defences … meant that the likelihood of manned aircraft getting through was diminishing rapidly ... By the second half of the 1960s, the days of the Vulcan and Victor as the primary deterrent were numbered. Polaris was used for the major strategic targets with the heaviest defences and we were assigned to less heavily defended, sub-strategic targets, such as regional command and control headquarters. We believed then, and I believe now, that this certainly did not mean the Soviet regime could ignore the threat from the V-Force – our targets were a very significant threat to their ability to retain overall control of their state machinery.[26]

[25] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; email: 12/8/19.
[26] Roger Dunsford, Vulcan Captain; amongst documents/text provided: 19/11/20.

Recovery and casualties

Aircrew views on post-strike recovery often blended fatalism with black humour. Nav/Plotter Bryan Montgomery talks about acceptance:

> Some of our targets were very long range, but why come back? We had our plans for the return, but it was all pie in the sky. We were briefed to return to an airfield at Aalborg, Denmark. For targets too far to allow recovery to such bases, due to fuel considerations, crews would continue flying east until, at a certain point over the Steppe of East Russia, they would abandon the aircraft and wait to be rescued by Allied forces. No-one thought much of this! Anyway, we didn't talk about it much as a crew.[27]

Nav/Radar Barry Mullen's crew had operational orders to return to base: "We talked about it from time to time, but when we discussed 'what if' options, these were merely thoughts. On one occasion, someone asked whether we would have enough fuel to reach the Bahamas."[28]

The 1971 Air Force Department submission to the Long Term Strategic Nuclear Working Party, proposing an air-delivered system as a Polaris successor, reviewed then current air-delivered strike capabilities in the broad context, including emergent nuclear powers in receipt of extensive Soviet military aid (with air defence weapons that would be encountered in a retaliatory strike against Russia, such as S.60 and ZSU guns and SA-3). It stated:

> … the primary threat comprises guns and SA-3 which may be encountered randomly en route if their precise locations are not known, so that they cannot be avoided by tactical routeing. They may also be encountered as fixed deployments in defence of city targets comprising a typical five SA-3 site complex and an assumed deployment of five to 10 S.60 gun batteries to provide all-round cover.[29]

Not surprisingly, Tornado was judged to be the least vulnerable in this operational environment, with the Vulcan, "our largest, slowest and inherently most vulnerable aircraft" at greatest risk. Four encounters with S.60 FLAP WHEEL batteries by day would demand a force requirement of four aircraft "to ensure at least one survivor" [30]. This is a statement of some significance, given that, in the 1960s, there would be very

[27] Bryan "Monty" Montgomery, Valiant Nav/Plotter, 148 Squadron (1962-65), RAF Marham; interviewed: 27/2/18.
[28] Barry Mullen, Vulcan Nav/Radar, IX Squadron, RAF Akrotiri; 50 Squadron, RAF Waddington; amongst documents/text provided: 29/10/20.
[29] AIR 2/19184, "Air-delivered strategic nuclear weapons systems", Air Force Department, September 1971.
[30] Ibid.

few V-bombers surviving a pre-emptive Soviet missile strike. Only a handful of bombers would have survived long enough to make an attack and, against this background, exclusive targeting of the two largest Soviet cities is logical, although, in the context of general war (as opposed to unilateral retaliation), Moscow and Leningrad would have been vaporised before the few remaining V-bombers arrived. All V-Force crews, of course, were familiar with tactics to attack Moscow and Leningrad, as these were the principal QRA targets for all squadrons.

Taken overall, these themes suggest that the outcome of a British retaliatory attack – making good the deterrent threat – would see a handful of bombers successfully deliver two or three weapons on Moscow and Leningrad. The consequences, in terms of damage and casualties, would differ greatly between Plan A and Plan B. Under Plan A, a small number of British weapons would have added little to the destruction already inflicted by American missiles. Under Plan B, in the absence of a US missile strike, the damage and casualties inflicted by British megaton class weapons on the two leading Soviet cities would have been catastrophic. It was judged sufficient to materially alter the balance of power between the USA and USSR. A focus on successful delivery of a few British weapons on the two largest Soviet cities was entirely appropriate. It made both political and military sense, given the small number of surviving V-bombers likely to be in a position to make an attack, the desire to maximise the destructive potential of the few weapons delivered, the priority need to deter war by presenting the maximum deterrent threat and, finally, the inability of the Soviets to count on the destruction of all penetrators.

In summary, this chapter describes how each surviving V-bomber would fight World War 3 alone, penetrating the coastal belt, area defences and, in the case of free-fallers, point defences, by flying in at extremely low level and maintaining electronic silence unless under direct threat. V-force training and exercises included the attack profiles required for successful weapons delivery, followed by the escape manoeuvre. Timings suggest that the bombers could survive blast, direct radiation and other effects from the detonation of their weapons, but only given sufficient TOT separation. In general war, the Soviet defences would suffer severe degradation. Certainly, in both general and unilateral contexts, PVO-Strany's defences could offer no *absolute guarantee* that every surviving V-bomber would be destroyed before weapon release over, in all probability, Moscow and Leningrad.

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TRAINING FOR A ONE-STRIKE WAR

Training, QRA, exercises and bombing/navigation competitions were the main themes of V-Force operational life. This chapter examines some of the preoccupations of operational crews. Systems and procedures for checking competence and efficiency, the content of training sorties and visits overseas are reviewed, together with attitudes towards deterrence and issues surrounding retaliatory attack, from ultra low flying to concerns about fuel and range.

The "Grand Tour"

In the primary role V-Force crews would fly only one war sortie: they trained for a one-strike nuclear war. Training had a global reach, from UK ranges such as Wainfleet and West Freugh and British cities "destroyed" thousands of times in simulated attacks, to Goose Bay in Labrador, El Adem in Libya and China Rock, off Singapore. V-bomber training was intense, continuous and with just one aim: successful delivery of a nuclear weapon. V-bomber flying hours were packed with training value and sorties often involved a "Grand Tour" of Britain, as recalled by Nav/Plotter Robin Woolven: "We kept to the UK low level routes and avoided danger areas, active airfields and overflying the crowded South East."[1]

Crews defended hard-won Crew Classification rankings. Valiant Nav/Plotter Bryan Montgomery belonged to a crack "Select Star" crew; each sortie counted in retaining their top status: "I remember flying as low as possible over the Welsh mountains and climbing to 10,000 ft to 'release' a weapon over Barrow."[2] RBSUs were modified AAA tracking radars (AA No. 3 Mk. 7, later succeeded by Radar Tracking System Mk. 2). Nav/Radar Norman Bonnor explains the system:

> Each RBSU covered a range of up to 40 targets of varying difficulty; crews could book attack times before take-off or call for an opportunity attack. Bomb release was simulated by the end of a tone transmitted by the aircraft on UHF, which automatically lifted a pen on the radar plotting table. The RBSU staff then used their tracking radar's values of track, speed and height to calculate the forward throw and trail of a simulated weapon and estimate the impact error.[3]

[1] Robin Woolven, Vulcan Nav/Plotter; amongst documents/text provided: 5/11/20.
[2] Bryan "Monty" Montgomery, Valiant Nav/Plotter; interviewed: 27/2/18.
[3] Norman Bonnor, Victor Nav/Radar; "The V-Force: 1955 to 1966: Navigation at 50,000 and 500 ft", article, V-Force Reunion, Newark Air Museum, May 17-18 2014.

Some of Vulcan Nav/Radar Roy Brocklebank's UK targets were scored by the RBSU at Haydock Park racecourse, Liverpool:

> We would run in on the bearing and the AA radar would lock on. This would be detected by our AEO, who would fire up Red Shrimp. He would then switch it off, to see if the missile lock had been broken. If they still had a lock, he'd have another go. In the USA, SAC bombers were tested against Nike SAM sites. Here, we used the gun-laying radars as the Bloodhound SAM radars were not compatible with our systems, making it impossible to affiliate.[4]

Crew efficiency was subject to constant monitoring. All Pilots were required for regular checks on the Vulcan simulator at RAF Coningsby. Navigators at Scampton had no need to travel to practice missile release, as the Blue Steel training rig was housed in this station's Operations Block.

Most V-Force aircrew had confidence in aircraft and systems. V-bomber Captain Nick Dennis, in considering his Vulcan's defensive capabilities, had faith in its manoeuvrability but wished for AAMs: "It seemed strange to train to attack the USSR in an aircraft without defensive weapons." At the same time, he, for one, was happy with the ECM: "I was impressed – and quite surprised at what it could achieve."[5]

Training sorties

There was always, however, a level of discontent amongst aircrew. Some complained about lack of flying hours. Others wanted a different style of flying. Vulcan Nav/Radar John Weller, with IX Squadron, recalls morale in No. 1 Group at a low ebb in 1965:

> A lot of training seemed to be about boring holes in the sky just for the sake of it. Then there were the Intelligence briefings. We were given the Soviet Order of Battle. On paper it looked horrendous. It was argued that, of the thousands of MiGs, only a third of them would work on the day. In contrast, we were demonstrating – as the deterrent – that we had the serviceability to put the aircraft in the air, but some of the sorties were a waste of time, particularly if aircraft unserviceability had delayed us until the ranges were closed...[6]

Vulcan Captain Roger Smith explains the context. In early 1963 he was engaged in advanced flying training in Vampires. This was at a time of V-Force expansion; 25 of the 27 course graduates were posted to the V-Force:

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[4] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.
[5] Nick Dennis, Vulcan Captain; interviewed: 30/5/18.
[6] John Weller, Vulcan Nav/Radar; interviewed: 1/8/18.

> Our perception was that all the V-Force did was to fly in straight lines at 50,000 ft, dropping radar bombs on radar targets, a view largely gained from our mainly ex-Fighter Command Instructors. Hence, those posted to the V-Force were devastated to think that a potentially exciting career flying Lightnings was not to be. In fact the adverse reaction was so strong that the Station Commander wrote to the MoD, complaining about the situation. V-Force postings were reduced from 25 to 23![7]

Smith felt depressed when he passed through RAF Finningley's gates, to join 230 Vulcan OCU, but a close encounter with the bomber prompted second thoughts: "Wow! It was April 1964 and this Vulcan looked spectacular in its white anti-flash. It looked even better camouflaged, as our role changed from high to low level." He became a 12 Squadron Co-Pilot:

> Obviously, I knew what the V-Force was all about, but that was never at the forefront of my mind at that time. I was in my very early twenties and all I wanted to do was get onto a squadron and fly the aeroplane ... The snag, however, was that we flew only four or five times a month, unless we were on detachment, when the flying was more intense.[8]

Wing Commander Peter West provides a detailed account of a V-Force TPF (Tactical Profile Flight):

> Usually, this consisted of a navigation phase, which took up about 70% of the flight, three radar bombing runs and either fighter affiliation or circuit training. Following take-off, we went straight into the nav phase which, sometimes post-1964, was flown over the low level route around the UK. The next phase of the flight was to attack targets, where we were monitored by ground radar sites, which measured the results and passed these to us on the radio … After three such bombing runs the aircraft usually returned to base, to allow the Pilots to practice landings and take-offs, this universally loathed by rear crews who had nothing to do but monitor flight instruments. If he was lucky, the AEO might be allowed to carry out a fighter affiliation. This involved calling up a Fighter Control Unit and asking for "Playmates" ... In my day, the fighters were usually F.4 Phantoms … On my last sortie with 12 Squadron, in 1966, we had an "all-out" game with pairs of F.4s over the North Sea. After 10 attacks, they had to return to base, low on fuel. The Fighter Controller broadcast: "I make that Christians 10, lions 0!" A great way to end my tour.[9]

The character of training changed when the Valiants were grounded in 1965. Training programme revisions were guided by caution over airframe fatigue and the need to

[7] Roger Smith, Vulcan Captain; interviewed: 11/12/18.
[8] Ibid.
[9] Peter West, Valiant/Vulcan AEO; letter: 6/5/19.

restrict low level flying hours. Blue Steel Victor Navigator Norman Bonnor remembers the switch in emphasis:

> Our training targets were dramatically changed, from one based primarily on hours and sorties to new definitions based strictly on training value. We were allowed no more than four sorties a month and each one had to be packed with high value training. The senior staff at Wittering thought this would lead to a drop in morale among the crews, but far from it. We no longer flew without a missile, or had to carry unserviceabilities …[10]

Norman Bonnor recalls the decision requiring each operational Blue Steel round on the station to be flown once every six months:

> When we flew with these "wet" missiles (without warheads, of course), rather than training rounds, HTP temperatures were one of the items checked and logged every 30 minutes throughout the sortie. Should the HTP temperatures start to rise whilst airborne, the crew would divert immediately to the nearest Blue Steel diversion airfield, to offload the HTP into large tanks of water buried in the ground close to the ORP.[11]

Vulcan crews enjoyed fighter affiliations, given that their aircraft was a bomber that thought it was a fighter. Pilot Nick Dennis remembers the rivalry with the "Lightning Boys":

> At that time, Lightnings had the Firestreak air-to-air missile – an infra-red guided weapon. If it locked on, the fighter pilot would call "Splash!", then ask for a vector back to Binbrook or another Air Defence base. Our aim was to avoid lock-on and we had all sorts of tricks up our sleeve. We would be at around 42,000-45,000 ft and the incoming Lightning would be at around 35,000 ft. We would see him – the AEO would get a positive from Red Steer. One tactic was to get over the top of him and lose speed, making it impossible for him to get behind us. If we could get behind the Lightning, we could call "Splash!" The Lightning had a spectacular performance and was a wonderful interceptor, but it had to stay on your tail with Firestreak. The later Red Top was different. With this weapon, the fighter could attack head-on. It was game over – there was no counter.[12]

Nav/Plotter Jim Milne confirmed that the Vulcan "could turn inside almost any opposing fighter of those days". He also had confidence in the EW kit, in sharp contrast to some: "I was amazed at just how good the ECM was. We used to check

[10] Norman Bonnor, Victor Nav/Radar; paper (undated), "Blue Steel, the V-Force's stand-off bomb."
[11] Ibid.
[12] Nick Dennis, Vulcan Captain; interviewed: 30/5/18.

out the kit over the Hebrides. When we got TFR, my Skipper was prepared to have a go with it, but it … made us a bit twitchy and we never used it at night."[13]

Barry Mullen became a Vulcan Nav/Radar:

> The six-month course included lectures on aircraft systems and radar, together with simulator time. The analogue simulators presented a series of "equipment failures". We had to diagnose these failures and, somehow, still drop the weapon and complete the mission ... We used "offsets", taken from a good radar reflection, to aim our aircraft at the target ... RAF Waddington had a simulator which allowed us to practise the switching for arming and dropping a nuclear weapon … The simulators at RAF Lindholme were designed for use by the Nav/Radar and Nav/Plotter … System failures could be introduced and it was the job of the Nav Team to get to the target and drop the simulated weapon.[14]

If called upon to do so, it would have been Barry Mullen's job to drop a weapon with the power to kill millions. V-Force aircrew underwent no psychological assessment:

> We were shown a film of the effects of the atomic bombing of Hiroshima and Nagasaki and I thought that was pretty horrific. But we were just young lads at the time, all with a certain mindset. Our job was to protect our country, as a non-aggressor. We never got worked up over politics … I suppose pragmatism was the order of the day.[15]

A one-shot system

In the early years, the V-Force planned to deliver up to three nuclear strikes. This changed with the dominance of missiles. There would be just one retaliatory attack, delivered by the survivors of a Soviet pre-emptive strike. Much later, under "Flexible Response" and the concept of showing resolve by possible first use of a few tactical nuclear weapons against overwhelming Soviet conventional attack, some strike aircraft could have undertaken "demonstration" missions, aiming to avoid an all-out nuclear exchange. At one level, the likely need to resort to sparing early use of tactical nuclear weapons reflected NATO's long-standing failure to provide adequate conventional war-fighting stocks. It was thought that the "30-day" NATO standard stock of munitions and other consumables might evaporate in just one week of intense conventional battle. This suggests depletion of stocks before the arrival of US reinforcements - so precipitating a demonstration nuclear release decision.[16]

[13] Jim Milne, Vulcan Nav/Plotter; interviewed: 5/4/18.
[14] Barry Mullen, Vulcan Nav/Radar; amongst documents/text provided: 29/10/20.
[15] Ibid.
[16] DASB/296/80, "UK Logistic Planning Policy", meeting of the Chiefs of Staff Committee, May 6 1980.

Most V-Force crews assumed they were training for a one-strike war, with "nothing left to come home to." Their business was flying, rather than policy, and the "buzz" of low flying provided an outlet for many, including Bryan Montgomery, a Nav/Plotter on Valiants: "Now the flying became more interesting. We would fly at around 250 ft over the Welsh mountains."[17] Dick Fuller, a Valiant Co-Pilot, remembers the aircraft being heavy on the controls: "The Valiant was a handful and there was plenty of turbulence."[18] Vulcan Nav/Radar Barry Mullen has a vivid recollection of low-flying:

> Low meant low – from 500 ft down to 300 ft. My main screen was photographed, to preserve our performance for later scrutiny. I was part of the "Terrain Following System". I set up the radar to scan directly in front of us. The black section visible on screen was what we were in danger of hitting. I then counted down the cut-off, from five to four and then three miles. It was at that point that I told the Captain to pull up. I was an insurance for the automated system.[19]

Vulcan AEO Hugh Prior was unconcerned when flying low: "That never worried me – if something happened at low level it would be over in an instant. I felt much the same about nuclear war."[20]

Threatening Southern Russia

As the 1960s drew to a close, with Polaris providing the nuclear frontline, two V-Force Vulcan squadrons, 35 and IX, moved to RAF Akrotiri, Cyprus - a welcome posting for aircrew and groundcrew alike. All aircraft were in Cyprus by mid-March 1969, replacing NEAF Strike Wing Canberras. In the nuclear role, these squadrons were required to generate 75% of available aircraft within 24 hours and the remainder as soon as possible (100% within 72 hours). Three armed aircraft would disperse to Muharraq (Bahrain) and six to Masirah Island, with the rest operating from Akrotiri. They would maintain NEAF Strategic Alert for up to 28 days.[21] RAF Akrotiri had acquired nuclear weapons storage facilities in 1961.[22] The Cyprus Vulcan squadrons were the only V-bomber units to have a permanent overseas base. Jim Walker was 35 Squadron's Radar Leader: "Cyprus was great – brilliant. In some ways it was like a flying club. By then, we knew the job inside out and the flying was routine. Our nuclear targets were in Southern Russia; some were long-range, including Tashkent

[17] Bryan "Monty" Montgomery, Valiant Nav/Plotter; interviewed: 27/2/18.
[18] Dick Fuller, Valiant Co-Pilot; amongst various documents/text provided: 29/10/20.
[19] Barry Mullen, Vulcan Nav/Radar; amongst documents/text provided: 29/10/20.
[20] Hugh Prior, Vulcan AEO; interviewed: 30/5/18.
[21] Wynn, *RAF nuclear deterrent forces*, 546.
[22] AIR 41/85, Humphrey Wynn, "The RAF in the postwar years", Air Historical Branch (RAF) (1984): 71.

and Kiev."[23] Nav/Radar Barry Mullen was single, free and seized his opportunity for a "sunshine tour". He joined the IX Squadron crew captained by Flight Lieutenant Fred Tiernan. Mullen was more than happy with his luck – which was better than some of the eight Cranwell Cadets who made up his intake. Three were to die in accidents. As a replacement Nav/Radar, Mullen's arrival was greeted with some uncertainty. However, on his first sortie he dropped all 28 lb practice bombs within 50 ft of the bombing range target. The AEO passed judgement, saying: "He'll do!"[24]

Cyprus Vulcans were armed with WE.177B hydrogen bombs but four WE.177A tactical weapons were sent out in October 1970 due to a shortage of higher yield weapons, as explained by nuclear weapons historian Mike Fazackerley:

> There was a gap – a period during which there were not enough WE.177Bs to go round. This was due to rotation of the Cyprus squadrons and some reorganisation following the retirement of Blue Steel. For a short period, there were 56 Vulcans and 52 WE.177Bs, including four spares. The situation resolved itself when 27 Squadron assumed its new role of long-range maritime reconnaissance.[25]

Communication was a worry for retaliatory forces based in Cyprus. According to Nav/Radar Roy Brocklebank, the planners allowed for communications problems in the case of a war scramble:

> It was thought that headquarters in Cyprus would have to take the initiative, in order to get the force airborne ... This led to new plans. They were based on how long you could afford to orbit over the sea between Cyprus and Turkey and still have adequate fuel reserves for completing the mission and landing back at base. For crews with Baku as their target, they had a couple of hours of flexibility. In contrast, those with targets as far away as Tashkent might have only minutes to tolerate a communications delay. When crews calculated their fuel plans, they would give two estimates; one was the time they could loiter and still recover with 4,000 lbs of fuel remaining. This was Delay 1. Delay 2 was the amount of time they could loiter, reach their target and fly on for a further 10 minutes before baling out. You could have heard a pin drop when this plan was unveiled to the assembled crews. It was the first time we had been briefed for one-way missions.[26]

[23] Jim Walker, Vulcan Nav/Radar; interviewed: 26/3/19.
[24] Barry Mullen, Vulcan Nav/Radar; amongst documents/text provided: 29/10/20.
[25] Mike Fazackerley, nuclear weapons historian; amongst documents/text provided: 15/11/20.
[26] Roy Brocklebank, Vulcan Nav/Radar, Wing Targeting Officer; amongst documents/text provided: 25/6/20.

The bombs were flown to Cyprus on a series of special flights by Hercules. They arrived during the night hours and were disguised.[27] The Cyprus V-Force came to an end following the 1974 Turkish invasion; the Vulcans returned to the UK.

Heading west

V-bomber training included "Western Rangers" – flying west to Goose Bay, Labrador, or USAF bases such as Offutt. British crews took part in USAF exercises and bombing competitions – adding a new dimension to the competitive spirit underlying performance on the squadrons. Participation in SAC bombing competitions was a highlight. Vulcan Co-Pilot Keith Mans remembered a high degree of confidence: "We thought we were better than them, but their aircraft had more modern ECM and inertial navigation. The competition was fierce and the participating V-bombers were always fitted with special equipment, to allow us to bomb more accurately. When comparing the B.52 and the V-bomber, the latter must have had a better chance on a war flight."[28]

Whilst on 100 Squadron, Nav/Radar Norman Bonnor's Victor crew flew several Western Rangers:

> Most crews made at least two visits to Goose Bay during a tour and, occasionally, on to Omaha and SAC Headquarters … We always first flew north out of Goose Bay, allowing us to climb and cross the US border at over 50,000 ft. We flew against the American Nike SAM defences, although they did require us to warn them when we were 100-150 miles out! We used our ECM and the Americans struggled. They had never encountered anything coming in at 57,000 ft. They were also impressed in other ways. For example, the Victor's weapons bay was almost as big as that of a B.52.[29]

V-bombers regularly tested American home defence fighters - they liked to dogfight. Vulcan Captain Rob Williams, however, particularly enjoyed the low levels over Goose Bay: "This part of the world is empty. There are fewer people in this wilderness than there are in the North African desert. It may be a lonely place but it offers excellent low-level flying. The regulations were firm – no flying lower than 200 ft. We followed the rules but I know that some didn't."[30]

[27] Bob Sinclair, Vulcan Nav/Radar; interviewed: 5/4/18.
[28] Keith Mans, Vulcan Co-Pilot; amongst documents/text provided: 17/11/20.
[29] Norman Bonnor, Victor Nav/Radar; amongst documents/text provided: 1/11/20.
[30] Rob Williams, Vulcan Captain; amongst documents/text provided: 27/10/20.

British bombers visiting Offutt AFB flew low level sorties "attacking" targets across the USA, using the USAF's network of "oilburner" routes.[31] One V-Force visitor, however, received a sharp lesson in the importance SAC attached to its Airborne Command Posts. AEO Martin Anscombe will not forget the incident:

> We burst a tyre on landing and asked for a tow (which was SOP), rather than taxi in, but we were ordered to clear the runway immediately as the next ACP was about to take off. Nothing was allowed to interfere with an ACP. We realised the importance of this when two large bulldozers appeared, heading towards us. If we didn't move, they would move us.[32]

As for bombing and navigation competitions, the British did well in "Giant Voice". In 1974, Vulcans won three of the four Giant Voice trophies. In competitions, as in love and war, "all is fair". The 1967 Giant Voice, for example, was to include both high level and low level attacks, but there were differing interpretations of "low level". During preparations British crews understood that low level would mean 2,500 ft, but target materials issued much later specified heights of between 4,000 ft and 7,100 ft, rendering the V-bombers' ultra low level "offset" practices inappropriate. So, final training sorties at "low level" used high level offset procedures. In effect, SAC's low level bombing heights were high level for the V-Force.[33] In the event, SAC cancelled the competition in late August. The British reciprocated. The rules for Bomber Command's Bombing and Navigation Competition were subject to constant change, leading to suggestions that they were designed to ensure visiting SAC crews couldn't win. The two sides kept a close eye on each other. Vulcan Captain Dennis Martin participated in a "Double Top" RAF/USAF exercise: "I flew as an Umpire in a B.52 making a low level attack at 500 ft over East Anglia. My job was to ensure there was no cheating." His Americans missed the target – "another one in the weeds."[34]

The Americans devised what was widely regarded as the most realistic battle experience possible in peacetime. During the mid-1970s the USAF began "Red Flag" battle practice within a Soviet air defence environment equipped with early warning radars, simulated SAM and AAA radars and "Aggressor Squadron" fighters using Soviet combat techniques. The attackers had to penetrate these defences and hit

[31] Air Vice-Marshal Nigel Baldwin, "Training the V-Force", RAF Historical Society, *Journal 20* (1999): 24-33.
[32] Martin Anscombe, Vulcan AEO; interviewed: 28/2/18.
[33] AIR 14/4401, Bomber Command, Operational Research Branch, Memorandum No. 345, "An analysis of training for Exercise Giant Voice", October 1967.
[34] Dennis Martin, Vulcan Captain; interviewed: 10/12/18.

targets across an extensive air-to-ground range north of Nellis AFB.[35] No. 1 Group sent bombers to each Red Flag. The results showed the Vulcan to be a potent weapon in favourable circumstances, even into the late 1970s. Air Vice-Marshal Nigel Baldwin: "… the Vulcan was rapidly becoming obsolescent (but) it still had one more shot in its locker … and it proved possible to much enhance the aircraft's ability to operate at low level at night and in bad weather." The Vulcans flew in Red Flag 79/2 – the first all-night sortie exercise in the series. Baldwin was Commander of 50 Squadron at the time and responsible for the work-up. There were no technical enhancements; they made do with the little-used basic TFR bought off the shelf 10 years before: "We worked up both confidence and experience gradually and certainly impressed our American hosts at Nellis AFB when we flew through the mountainous Red Flag ranges, contour flying at night at 1,000 feet agl – well below the B.52s and most of the F.111s."[36]

The Vulcan could still surprise, as discovered by an F.5 Aggressor pilot who had been chasing one at low level for some time, unable to launch a missile or attack with guns. Vulcan AEO Julian Grenfell: "… all of a sudden the sky filled with silver!" During debrief, the American fighter pilot described what had ensued:

> He went on to say that he was so frightened by this sudden event that he pushed his throttles forward to maximum and climbed away. His aircraft was shaking violently (so was he!) and it was not until he had calmed down, at some 30,000 ft, that he realised his airbrakes were still out and that the silver was chaff! The Vulcan, by then, had long gone.[37]

The V-bombers were largely unchanged: there were no major upgrades – in contrast to the B.52. V-bomber Pilot Philip Goodall had been seconded to the USAF and SAC. On his return to the UK he reported on the contrast between British policy regarding the Vulcan and American updating of the B.52 fleet - which gave positive results over Vietnam: "Certainly, modifications to G and H models is continuing to ensure better penetration and survivability in the more demanding primary role."[38]

Going east

When the V-bombers went east, to the Middle East or Far East, their trips were known as "Lone Rangers". These flights underlined V-Force nuclear and conventional roles

[35] White, *The King's thunderbolts*, 184-185.
[36] Baldwin, "Training the V-Force", 24-33.
[37] Julian Grenfell, Vulcan AEO; email: 20/4/19.
[38] Goodall, *My target was Leningrad*, 159-160.

in support of CENTO (Central Treaty Organization) and SEATO (Southeast Asia Treaty Organization). There were also longer detachments to bases such as Singapore. Furthermore, the Akrotiri Bomber Wing operated for five years, from 1969 until the Turkish invasion of Cyprus. Lone Rangers reflected the very different political maps of the 1960s and 1970s. Low level training, for example, included detachment to Luqa, Malta, or El Adem, to fly routes over pre-Gadaffi Libya.[39] Iran, ruled by the Shah, was another V-Force destination.

Lone Rangers and detachments in the CENTO/SEATO regions reflected the underlying nuclear strike role. Nuclear weapons were stored at Singapore. There were 48 Red Beard tactical weapons at Tengah (where they stayed until 1970). The planners considered their eventual replacement with WE.177.[40] By 1973, however, Tengah had transferred to the Singapore Air Force. Vulcan Captain John Huggins remembered his targets: "They included the valley passes in Burma. Our job was to stop Chinese armies entering Burma, to invade India."[41]

Belief in deterrence

Flying on the nuclear frontline meant buying into a wartime mentality during peacetime. It meant training to fight a war in the hope of never having to do so. Most believed it would never happen – why start a war with no winners? The deeper issues surrounding deterrence were pushed aside by young men with other priorities. John Huggins recalls a general lack of education about the Cold War: "No-one talked to us about nuclear war or the theory of deterrence … We knew a deterrent worked only when an enemy believes the threat is real. This is the way to keep the peace. The Russians had to believe we could do it and, furthermore, were fully prepared to do it."[42]

When Navigator Robin Woolven joined 617 Squadron and its Blue Steel-armed Vulcans in the Spring of 1964, he had no issues with his new role: "I took the view that it was our job to defend the nation ... I can recall no arguments about the ethics or righteousness of our role on the nuclear frontline. Of course, it was over 50 years ago – that's the way the world was at that time. We lived through the Cold War and that's what we trained for."[43] Nav/Radar Alan McLoughlin was also free of doubt: "I

[39] Baldwin, "*Training the V-Force",* 24-33.
[40] Stoddart, *Losing an empire and finding a role*, 99.
[41] John Huggins, Vulcan Captain; amongst documents/text provided: 26/10/20.
[42] Ibid.
[43] Robin Woolven, Vulcan Nav/Plotter; amongst documents/text provided: 5/11/20.

felt the same way as everyone else. I was entirely sold on the idea of deterrence. To my knowledge, no-one raised doubts."[44]

Vulcan AEO Barry Masefield had spent years flying maritime patrols and was a hardened Cold War veteran:

> Some people got quite excited about deterrence and the "bucket of sunshine" in the Vulcan's bomb-bay. That was not the case with me. I had been Cold War flying since 1965, locating Soviet surface vessels and submarines. Their behaviour was quite aggressive at times, but, in my heart of hearts, I never thought that deterrence would fail.[45]

When questioned, aircrew contributors to this research said that few men on the squadrons thought they would ever be called upon to fly a war sortie. They had a firm belief in deterrence. Equally, no-one could be *absolutely* sure it would never happen – perhaps accidentally. Air Commodore Edward Jarron, a former Vulcan Pilot, has distinct and strong views on this matter:

> I dispute the idea that most crews believed it would never happen. All the crews I knew had had conversations that faced up to the fact that we were training for a nuclear strike. However, we judged that we were in the business of deterring nuclear attacks against us. Although the likelihood of being scrambled on a war mission was low, that's quite different from convincing yourself that it will never happen. A credible deterrent requires everyone in the command chain, including the crews who will fly the missions, to sign up to the idea that they could be required to carry out a nuclear attack.[46]

The threat was real enough, as were the targets – which remain in many minds, including that of Pilot John Laycock: "Target Study was central to our lives and the capitals of the Baltic States were on the list. Tallinn was my primary target for a while. Archangel was another and Odessa was a third. I had many targets over the years. I would have dropped the weapon – absolutely!"[47]

Nuclear deterrence (so far, at least) has an impeccable record and Vulcan Co-Pilot Keith Mans remains convinced:

> The history of warfare is not that complicated ... Deterrence relies on convincing the other side that you have both the commitment and resolve to respond. I've always thought that a central element of deterrence is the ability to signal clearly

[44] Alan McLoughlin, Victor tanker Nav/Radar, 214 Squadron, RAF Marham; amongst documents/text provided: 2/11/20.
[45] Barry Masefield, Vulcan AEO; interviewed: 27/2/18.
[46] Edward Jarron, Vulcan Pilot, Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[47] John Laycock, Victor/Vulcan Captain; interviewed: 27/3/18.

> to the enemy the seriousness of your intentions. If you deploy and demonstrate effectively, deterrence can work in both conventional and nuclear environments.[48]

Nuclear "signalling", an important issue, does much to explain the longevity of the Vulcan force following the handover to Polaris. Some sharp minds have straightforward views on the broad value of the V-Force post-Polaris. Edward Jarron was Chief of Special Weapons at SHAPE in the early 1990s: "The V-Force had a conventional attack role … and a tactical nuclear deterrent role. Its most significant contribution, post-Polaris, was its visibility, in contrast to the submarines. This gave it an important 'nuclear signalling' role. In a world of 'flexible response'… it was another means of keeping the enemy guessing."[49]

Most politicians and military chiefs, having recognised Polaris as a secure deterrent solution with a virtually guaranteed strike outcome, were content for the post-1969 V-Force to continue as a secondary and usefully visible means of delivery. Vulcans excelled in "nuclear signalling", which required no costly upgrades of war-fighting performance. Noisy public displays of the Vulcan were impressive and cost next to nothing.

The Vulcan threat remained in being until the early 1980s and remained credible in a night/IMC attack scenario. Tim McLelland (2016) summed up V-Force positioning post-1969:

> …with their arsenal of WE.177s, the Vulcan force presented the East with a formidable presence. It was to assume a pseudo–tactical role that fitted neatly between the Navy's Polaris long range strike missiles and RAF Germany's tactical strike Buccaneers (later replaced by Phantoms and Jaguars).[50]

In 1999, Air Vice-Marshal Nigel Baldwin posed questions relating to V-Force capability and credibility: "Did the V-Force do the *right* training? Could we have got through the Soviet defences at low-level to the target on time?" He attempted an answer:

> I suppose that all training turns out to be flawed to some degree when the system is actually put to the test. Operational experience would certainly have revealed that some of our techniques could have been improved – except, of course, that in World War 3 it would have been a one-shot system. My own

[48] Keith Mans, Vulcan Co-Pilot; amongst documents/text provided: 17/11/20.
[49] Edward Jarron, Vulcan Pilot, Chief of Special Weapons, SHAPE; interviewed: 23/7/19.
[50] McLelland, *Britain's Cold War bombers*, 175.

> view, given reinforcement by our experience on the night Red Flag and by subsequent night training, is that our training was essentially right and, remembering all the peacetime constraints, that we did about the right amount of it. We had both *quality* and *quantity* enough to ensure that a proportion of us *would* have been able to reach our targets … especially if we had been launched at night or in poor visibility by day. I think that that was still true right to the end of the Vulcan's life.[51]

V-Force aircrew did their best with Ground Alert and they were supported by many sound measures to increase their chances of surviving a war scramble, including provision of ORPs, Telescramble and SIMSTART. Yet, this contrasts with failures to secure other improvements within easy reach and at modest cost. Competitive penny-pinching prevailed. Even the basics - sufficient RAF Police to guard armed aircraft and enough telephones for rapid call-out - provoked heated debate and hand-wringing. Funds should have been found to provide aircrew accommodation next to aircraft and reliable crew transport. V-bomber bases varied enormously in layout and facilities, but these differences were allowed to have an undue and disproportionate influence on QRA and Alert and Readiness.

In conclusion, operational aircrew understood they were training for a one-strike war, with very little chance of coming back if war came. Equally, most were convinced that deterrence would hold and that they would not be required to fly a war sortie. There is strong oral evidence to show that V-Force Crew Classification did much to encourage the natural desire to excel in the various aircrew disciplines. Bombing and navigation competitions were another positive stimulus. These factors helped offset negative influences on morale, including resistance to a V-Force posting amongst those wanting fighters, restrictions on personal freedoms imposed under the onerous Alert and Readiness regime and failures to provide the accommodation and other facilities commensurate with V-Force significance. Yet, in a very British way, these shortcomings were often set aside, as part and parcel of service life.

[51] Baldwin, "*Training the V-Force*": 24-33.

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CONCLUSION

"To what degree did the RAF maintain V-Force operational effectiveness in the 1960s?"

Bomber Command's ORB reported frequently on MBF operational effectiveness during the 1960s. ORB reports, taken with V-Force aircrew testimony, support the view that the MBF maintained a core capability (even in the unilateral context) to successfully deliver megaton class weapons on the Soviet Union's largest cities.

Moscow and Leningrad remained under MBF deterrent threat until the advent of Polaris in mid-1969, despite the fact that few V-bombers would have survived a pre-emptive missile strike and the subsequent attentions of Soviet defences.

The evidence points to the co-existence of two "scenarios" of MBF operational effectiveness during the six-year wait for Polaris. The PUBLIC presentation of the V-Force, optimistic in tone, was founded on favourable assumptions:

1. *The Soviets would adopt a simultaneous burst (US/Europe) attack mode, so gifting Western Europe the longer "American warning".*

This was the public justification for MBF Readiness State 15 minutes. It assumed that many V-bombers would escape destruction on the ground in a Soviet staggered launch pre-emptive attack - despite the absence of military advantage in *simultaneous burst*, which would mean foregoing the chance to destroy the vast majority of UK/West European nuclear assets in a short warning *simultaneous launch*. It seems that RS15 was a "device". It offered enough space for the V-Force to adopt practical readiness regimes adequate for training and exercises, but it was recognised as inadequate in a "four-minute warning" war context.

2. *There would be no "bolt from the blue" attack but, rather, time during a period of increasing tension to generate aircraft and weapons, disperse the V-Force and*

regenerate weapon systems to RS15 (with the possibility of going to Alert Condition 1: holding a proportion of aircraft at Cockpit Readiness, RS05).

Alert Condition 1 recognised the true significance of RS05 – rather than RS15 - in relation to the more likely four-minute warning, but assumed the political will to order dispersal (as was lacking during the Cuban Crisis - the only test of resolve in this matter).

3. *The ability to scramble V-Bomber flights in just less than two minutes would guarantee a high rate of survival.*

This ignored realities: the time required for RS15 crews to reach aircraft, man cockpits, complete checks, start engines and position for take-off. A simultaneous burst, staggered launch (providing an "American warning" - an additional seven to 12½ minutes) would allow a proportion of MBF aircraft held at RS15 to survive a war scramble. In contrast, very few bombers would survive the more likely simultaneous launch attack (a warning of four minutes or less). Advanced Cockpit Readiness was essential for any chance of survival. This required crew rotation: continuous manning of some aircraft at RS05, poised for engine start. There were sufficient crews to double-crew around 24 aircraft and single-crew the rest. Deep concern over exposure to destruction on the ground had driven studies of Airborne Alert and dispersal to remote bases overseas, but both lacked viability. The only practical posture in a grave crisis was "emergency Readiness" (RS05, poised for engine start, maintained continuously by crew rotation) for around one-third of the force (the maximum number possible). The fact that Alert Condition 1 – with its RS05 component – was introduced in 1961 is clear evidence of recognition that QRA at RS15, introduced the following year, was a "presentational convenience", but known to be inappropriate in relation to the low trajectory/simultaneous launch threat. In short, Alert Condition 1 increased V-Force credibility in response to low trajectory IRBM exposure.

4. *An ultra-low (300 ft or less) penetration and attack would allow most war scramble survivors to escape destruction by SAMs, fighters and guns.*

This ignored Soviet progress in strengthening low level air defence capabilities during the 1960s, including the introduction of more advanced radars and SAM systems. It also ignored the failure to provide V-bombers with a comprehensive, upgraded

defensive EW suite, appropriate to low level penetration of heavily defended airspace. Equally, ultra low level did offer the best chance of successful weapons delivery.

The favourable assumptions were used by politicians and military commanders to project the image of a credible deterrent to the Soviet Union, the public at home, V-bomber aircrew and the Americans. This optimistic public picture contrasted with the PRIVATE, less positive scenario:

1. *The most likely warning time (simultaneous launch attack) was four minutes or less (exactly what the British public had been told to expect).*

Planners recognised that the optimised Ground Alert posture when under imminent threat of Soviet nuclear attack would be full dispersal, with prominence given to geographically favoured airfields receiving bombers with priority targets (almost certainly Moscow and Leningrad), the aircraft being held 24/7 at RS05 through crew rotation, with all cockpit checks completed up to engine start.

2. *The best that could be hoped for (assuming main force dispersal and continuous RS05 for 25-30% of the force) would be the war scramble survival of perhaps 10% of aircraft, those "at the front of the queue" on airfields in the north and west (assuming late detonations over some airfields).*

Any attempt to profile a war sortie outcome must be founded on certain assumptions. The challenge is to select *realistic, appropriate assumptions*. Given a Soviet simultaneous launch of low trajectory IRBMs, a "four-minute warning", a dispersed V-Force at the highest possible Ground Alert posture (RS15 or better, but RS05 Cockpit Readiness for around 24 aircraft with Flight Alert priority targets and continuously manned by crew rotation - all checks completed and poised for RS02 engine start and scramble), the following *might* apply:

- **One minute 30 seconds**: warning of incoming missiles, a short delay in response and initial BMEWS verification of warning, transmission of RS02 (start engines) and a virtually simultaneous scramble order.
- **One minute 30 seconds**: engine start, allowance of a short airfield delay, scramble verification by crews, positioning for take-off, BMEWS confirmation of warning (no cancellation of scramble).
- **One minute**: for take-off.

- **One minute**: to achieve survival distance (assuming flyaway in the climb and avoidance of “infill” missile bursts).

The shortest total elapsed time from BMEWS warning to achievement of escape distance would be four to five minutes (probably much closer to five). Assuming airfields in the northern and western regions receive around four minutes 30 seconds warning and given missile arrival over a two-minute period (simultaneous burst on targets being impossible to achieve), a few MBF dispersal airfields might receive a getaway time of up to 6½ minutes, thus allowing a few aircraft to get away. Almost certainly, survival would require some component of “late burst time”.

3. *The evidence suggests perhaps 90% casualties on the ground. Given a generation strength of 80 bombers, war scramble survivors might number around eight V-bombers (with a warload of perhaps 5 MT). Britain’s punishment of the Soviet Union might be delivered by as few as 40 men. Assuming 50% casualties during penetration and attack (realistic in a SIOP retaliatory attack but, perhaps, a little over-optimistic in a National Plan attack made against intact defences), there was a potential to deliver up to four megaton class weapons on Moscow and Leningrad.*

The consequences of successful attacks by a handful of V-bombers differ greatly in SIOP and unilateral contexts. In a NATO all-out retaliatory attack, Soviet air defences would have been much degraded by American missile strikes before the surviving V-bombers began their penetrations. Whilst this would increase their chances of successful weapons delivery, these weapons would have added little to the West’s attack weight and, consequently, the damage inflicted. In short, hundreds of missile strikes would have “devalued” the SIOP threat from a handful of British bombers). In a National Plan unilateral attack, however, intact Soviet defences would pose a somewhat greater threat to the small group of surviving V-Force penetrators, but the successful penetration of even two or three bombers would inflict catastrophic damage. It is reasonable to assume that Soviet analysts saw through the V-Force public profile, given the obvious MBF exposure to destruction by low trajectory IRBMs, yet recognised the credibility of the core threat: successful delivery of perhaps 2-3 million tonnes of high explosive equivalent on the USSR’s first and second cities.

This core threat was the fundamental measure of MBF operational effectiveness. The V-Force task was to deliver the core threat, however defined at the given time. *It would be wrong to suggest that the potential to detonate megaton weapons over Moscow and Leningrad represents a poor return for investment in the V-Force.* This potential is in line with JIC judgements of unacceptable damage, at levels sufficient to undermine the balance between the superpowers. For most of the 1960s, each squadron of eight V-bombers was armed with 3.6 or 8.8 million tonnes of high explosive equivalent (depending on weapon type carried). The escape of just one in 10 bombers in a war scramble might well have resulted in the destruction of Moscow and Leningrad. Regardless of the strength of Soviet defences, there could be no guarantee that EVERY penetrating V-bomber would be destroyed before weapon release. In the final analysis, the interception of low level penetrators remained largely a matter of chance.

The maintenance of the ability to successfully deliver several British weapons on Moscow and Leningrad in the 1960s, even in the absence of the Americans, is the crucial issue in addressing the research question. Within two hours of a Soviet nuclear attack, a few surviving V-bombers attacking Moscow and Leningrad could have dropped the explosive equivalent of all the bombs dropped by the Allies on Germany in six years of war. This core threat was credible, under a highly evolved British definition of the ability to inflict unacceptable damage. This was distilled into the capacity to destroy large areas of Moscow and Leningrad and, in so doing, unilaterally undermine the balance between the superpowers. This was regarded as threat enough until Polaris arrived. Furthermore, the threat was maintained without recourse to significant additional investment in the MBF and its weapons.

As for V-Force crews, they were not fully briefed on the realities of war scramble survival, or tactics required for successful “flyaway” (a 40 deg. bank turn and climb to at least 5,000 ft within a “distribution cone”). These are inexcusable failings which have no explanation in the documentary record consulted. There were obvious reasons, relating to morale, for not sharing certain information, such as the poor prospects for scramble survival, plans for manipulating TOT, new Soviet low level SAMs and other negatives. The policy of providing no defensive weapons for the V-bombers was maintained. There was no major upgrade of ECM to cope with new low level-capable SAMs. The aircrew war-fighting task had been rendered down: to avoid incineration long enough to incinerate targets which, almost certainly, were already incinerated, given the outbreak of general war. At the same time, the main targets,

Moscow and Leningrad, would have been intact and under grave threat in the unlikely event of a unilateral V-bomber attack.

Pragmatic policy-makers and decision-takers saw no value in enhancing MBF war-fighting capabilities (which might, at best, have put one or two additional weapons on targets). In this sense, the V-Force can be viewed as an extraordinary strategic defence bargain. Rather than invest in hardware (aircraft, weapons and systems), the core threat against the Soviet first and second cities was maintained through the adoption of extreme combat tactics. There was very little additional spend on the V-Force and its nuclear strike capability (which had already permitted substantial budget cuts for conventional forces).

The primary role of the V-Force was to deter, rather than war-fight. It was enough, pre-Polaris handover, that the Soviets should recognise that a few British bombers might get through (even in a unilateral retaliatory attack) and that their main targets, almost certainly, would be Moscow and Leningrad. The threat turned on what a few surviving V-bombers might accomplish alone.

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Bonnor, Air Commodore Norman, FRIN, FRAeS, Victor Nav/Radar, XV Squadron, 100 Squadron; 1/11/20.

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Bussereau, Vic, Vulcan Nav/Radar, 35 Squadron, 50 Squadron; 20/4/19.

Cottingham, Tony, Valiant Co-Pilot, 49 Squadron; Captain, 7 Squadron; 23/3/19.

Dennis, Nick, Vulcan Co-Pilot, 12 Squadron; Captain, 44 (Rhodesia) Squadron; 24/7/18.
Dinmore, David, Vulcan Co-Pilot, 35 Squadron; Captain, 44 (Rhodesia) Squadron; 11/6/19.
Doe, Cliff, Vulcan Crew Chief, 35 Squadron; 19/6/19.
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Jarron, Air Commodore Edward, Vulcan Pilot; Assistant Air Attaché in Moscow during the mid-1970s; Station Commander, RAF Cranwell (1989-90); Chief of Special Weapons, SHAPE (1992); 2/9/19.

Langdown, Paddy, Vulcan Co-Pilot/First Pilot, 35 Squadron; Captain, 50 Squadron, 101 Squadron; 20/2/18.
Laycock, John, Victor Co-Pilot and Captain, XV Squadron; Vulcan Captain and Flight Commander, 44 (Rhodesia) Squadron; 3/9/18.

Mans, Keith, Vulcan Co-Pilot, 50 Squadron; 17/11/20.
Martin, Dennis, Vulcan Co-Pilot, 50 Squadron; Captain, IX Squadron; 18/1/19.
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