BOMBER COMMAND’S ELECTRONIC WARFARE POLICY AND SUPPRESSION OF ENEMY AIR DEFENCE POSTURE DURING THE SECOND WORLD WAR

By

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ABSTRACT

This thesis will examine the Electronic Warfare [EW] policies and subsequent Suppression of Enemy Air Defence [SEAD] postures of the Royal Air Force's Bomber Command during the Second World War. It examines how EW was applied to the *Luftwaffe* (German Air Force) Integrated Air Defence System [IADS] so as to reduce Bomber Command aircraft losses, and determines whether EW policies were drafted in a proactive and/or reactive fashion *vis-à-vis* the *Luftwaffe* IADS. The thesis applies air power theory regarding the levels and methods of application by which SEAD was brought to bear against the IADS as a result of these EW policies. Ultimately, the thesis will argue that Bomber Command enacted both proactive and reactive EW policies at the Campaign and Localised SEAD levels using a combination of Manoeuvrist, Mass and Stealth/Surprise approaches.

DEDICATION

For Brian Withington and Stephen Benn who knew only too well the strength of the *Luftwaffe*.

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give thanks; please accept my humble apologies and gratitude. Finally, any and all errors remain the author's responsibility.

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GLOSSARY

AAA -	Anti-Aircraft Artillery
ACAS (Ops) -	Assistant Chief of the Air Staff (Operations)
AEAF -	Allied Expeditionary Air Force
AI -	Airborne Interception radar
Air Cdre. -	Air Commodore
AIRBORNE CIGAR/ABC -	An airborne electronic countermeasure designed to jam *Luftwaffe* radio communications.
AIRBORNE GROCER/ABG -	An airborne electronic countermeasure designed to jam *Luftwaffe* Airborne Interception radar.
AM -	Air Marshal
AOC -	Air Officer Commanding
AOC-in-C -	Air Officer Commanding-in-Chief
AOR -	Area of Responsibility
ARM -	Anti-Radiation Missile
AVM -	Air Vice Marshal
BAGFUL -	An airborne electronic intelligence gathering system.
BENITO -	A *Luftwaffe* radio navigation system
BLONDE –	An enhanced ground-based and airborne version of the BAGFUL airborne electronic intelligence gathering system.
BSDU -	Bomber Support Development Unit
C2 -	Command and Control

CAP -	Combat Air Patrol
CARPET -	An electronic countermeasure designed to jam *Luftwaffe* Fire Control/Ground Controlled Interception radars.
CARPET-II/III -	A variant of the CARPET electronic countermeasure designed to jam *Luftwaffe* Fire Control/Ground Controlled Interception radars supporting Anti-Aircraft Artillery.
CAS -	Close Air Support
CHAIN HOME -	The RAF's Second World War ground-based air surveillance radar network.
CIRCUS -	RAF Fighter Command operations over occupied Europe intended to force the *Luftwaffe* into battle.
COMINT -	Communications Intelligence
CORONA -	A ground-based electronic countermeasure designed to jam *Luftwaffe* high frequency radio.
CSO -	Chief Signals Officer
CSTC -	Combined Strategic Targets Committee
D of Tels -	Director of Telecommunications
DARTBOARD/LIGHT-UP -	A ground-based electronic countermeasure designed to jam *Luftwaffe* Medium Frequency radio communications.
DCAS -	Deputy Chief of the Air Staff

DRUMSTICK -	A ground-based electronic countermeasure designed to jam *Luftwaffe* high frequency Morse code wireless telephony traffic.
EA -	Electronic Attack
ECM -	Electronic Countermeasure
ECCM -	Electronic Counter-Countermeasure
ELINT -	Electronic Intelligence
EM -	Electromagnetic
EP -	Electronic Protection
ES -	Electronic Support
ESM -	Electronic Support Measure
EW -	Electronic Warfare
FAA -	*Fuerza Aérea Argentina*/Argentine Air Force
FC/GCI -	Fire Control/Ground Controlled Interception radar
FIDGET -	A ground-based electronic countermeasure designed to jam *Luftwaffe* radio beacons.
FuG-202 *Lichtenstein-BC* -	*Luftwaffe* airborne interception radar
FuMG *Freya Fahrstuhl* -	*Luftwaffe* ground-based air surveillance radar
FuMG-62D *Würzburg* -	*Luftwaffe* fire-control/ground controlled interception radar
FuMG-65 *Würzburg Riese* -	*Luftwaffe* fire-control/ground controlled interception radar
FuMG-80 *Freya* -	*Luftwaffe* ground-based air surveillance radar
FuMG-402 *Wasserman* -	*Luftwaffe* ground-based air surveillance radar

FuMG-404 *Jagdschloss* -	*Luftwaffe* ground-based air surveillance radar
FuMo-51 *Mammut* -	*Luftwaffe* ground-based air surveillance radar
GBAD -	Ground-Based Air Defence
GCI -	Ground Controlled Interception
GEE -	RAF radio navigation system
GHz -	Gigahertz
Gp. Capt -	Group Captain
GROUND CARPET -	A ground-based electronic countermeasure designed to jam *Luftwaffe* fire control/ground controlled interception radar.
GROUND CIGAR -	A ground-based electronic countermeasure designed to jam *Luftwaffe* VHF radio communications.
GROUND GROCER -	A ground-based electronic countermeasure designed to jam *Luftwaffe* airborne interception radar.
GROUND MANDREL -	A ground-based electronic countermeasures designed to jam *Luftwaffe* ground-based air surveillance radar.
HF -	High Frequency (three to 30 Megahertz)
IADS -	Integrated Air Defence System
IAF -	Israeli Air Force
IFF -	Identification Friend or Foe
INTRUDER -	RAF fighter-bomber kinetic attacks against *Luftwaffe* fighters and airfields.

JOSTLE-IV -	An airborne electronic countermeasure designed to jam *Luftwaffe* high frequency and very high frequency voice radio communications.
Kleine Schraube -	*Luftwaffe* fighter control radio beacon
MANDREL -	An airborne electronic countermeasure designed to jam *Luftwaffe* ground-based air surveillance radars.
MF -	Medium Frequency (three kilohertz to three megahertz)
MHz -	Megahertz
MONICA -	Tail warning radar
MOONSHINE -	An airborne electronic countermeasure designed to jam *Luftwaffe* ground-based air surveillance radar.
NATO -	North Atlantic Treaty Organisation
OCA -	Offensive Counter Air
ORBAT -	Order of Battle
ORS -	Operational Research Section
OTTOKAR -	*Luftwaffe* radio navigation system
PIPERACK -	An electronic countermeasure designed to jam *Luftwaffe* airborne interception radar.
RAF -	Royal Air Force
RAP -	Recognised Air Picture
RAYON -	A ground-based electronic countermeasure designed to jam *Luftwaffe* radio navigation.
RCM -	Radio Counter Measure (wartime name for ECM)
RCS -	Radar Cross Section

RDF -	Radio Direction Finding: an early name for radar.
RF -	Radio Frequency
R/T -	Radio Telephony (voice radio communications)
RWR -	Radar Warning Receiver
SAM -	Surface-to-Air Missile
SEAD -	Suppression of Enemy Air Defence
SERRATE -	A radar warning receiver designed to detect *Luftwaffe* airborne interception radar.
SHAEF -	Supreme Headquarters Allied Expeditionary Force
SIGINT -	Signals Intelligence
SPECIAL TINSEL -	A ground-based electronic countermeasure designed to jam *Luftwaffe* high frequency radar communications.
SSM -	Surface-to-Surface Missile
SWF -	Special WINDOW Force
TINSEL -	An airborne electronic countermeasure designed to jam *Luftwaffe* radio communications.
TRE -	Telecommunications Research Establishment
UARAF -	United Arab Republic Air Force
UAV -	Unmanned Aerial Vehicle
UHF -	Ultra High Frequency (300MHz to 3GHz)
USAAF -	United States Army Air Force
USAF -	United States Air Force
USMC -	United States Marine Corps
USN -	United States Navy

USSTAF -	United States Strategic Air Forces
VHF -	Very High Frequency (30MHz to 300MHz)
WAP -	Western Air Plan
WINDOW -	An airborne electronic countermeasure initially designed to jam *Luftwaffe* fire control/ground controlled interception radar, but later enhanced to jam other ground-based air surveillance and airborne interception radar types.
W/T -	Wireless Telephony (Morse code radio communications)
Y-Service -	The RAF's ELINT gathering service.

INTRODUCTION

Summary

This thesis will examine the Electronic Warfare [EW] policies and subsequent Suppression of Enemy Air Defence [SEAD] posture of the Royal Air Force's [RAF] Bomber Command during the Second World War. It will argue that during the conflict the Command enacted both proactive and reactive EW policies at the Campaign and Localised SEAD levels using a combination of Manoeuvrist, Mass and Stealth/Surprise approaches. This introduction will outline the thesis' scope and terms of reference, detail and examine omissions in the existing canon of literature covering the Command's EW efforts during the conflict, detail the thesis' structure and the methodology to be employed.

EW and SEAD

The term 'Electronic Warfare' used in the opening paragraph refers to 'any military action that involves the use or control of the EM [Electromagnetic] spectrum to reduce or prevent hostile use or to attack the enemy,' according to the Royal Air Force publication *Air and Space Warfare*.[1] Air Marshal Frederick Sowery presented a similar definition, and posited that EW is 'the exploitation of the electromagnetic spectrum and the denial of its use to the enemy'.[2]

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[1] Air Warfare Centre, *Air and Space Warfare: AP3002* (Second Edition: RAF Waddington: Royal Air Force, 2009), chapter 10-23.
[2] F. Sowery, 'Introduction', *Royal Air Force Historical Society Journal*, 28 (2003), p.13.

EW contains three components; Electronic Attack, Electronic Protection and Electronic Support. Regarding air warfare; 'airborne EW is used to enhance the survivability of aircraft and ground assets and to improve mission effectiveness'. Electronic Attack employs the EM spectrum 'to attack personnel, facilities or equipment with the intent of degrading, neutralizing or destroying combat capability'. In practice, this involves the use of electronic emissions in the form of Radio Frequency [RF] energy, to cause this degradation, neutralisation and/or destruction; processes popularly referred to as 'jamming'. During the Second World War, Bomber Command employed RF energy to perform electronic attacks against hostile radar, and radio communications and radio navigation systems across the Medium Frequency, High Frequency [HF], Very High Frequency [VHF] and parts of the Ultra High Frequency [UHF] wavebands of the EM spectrum. These wavebands encompassed the frequencies used by *Luftwaffe* (German Air Force) ground-based air surveillance, Fire-Control/Ground Controlled Interception [FC/GCI] and Airborne Interception [AI] radar, and its air-to-ground/ground-to-air fighter radio communications, and radio navigation systems. All of these systems constituted the electronic elements of the *Luftwaffe's* Integrated Air Defence System [IADS] which protected German territory and territorial possessions in Occupied Europe.[3]

Electronic Protection 'involves all actions taken to protect personnel, facilities and equipment from any effects of friendly or enemy employment of EW that degrade, neutralize or destroy friendly combat capabilities'. These actions can take the form of the employment of active and passive EW techniques. Active EW techniques use electronic attack (*see above*) to protect friendly aircraft from detection by hostile radar. During the war Bomber Command employed

[3] Air Warfare Centre, chapter 10-23.

RF energy to jam hostile radar and radio communications. As the discussion below articulates, several aircraft subsystems, known at the time as Radio Countermeasures, but today called Electronic Countermeasures [ECMs], were developed during the conflict and were used for this purpose. Passive EW techniques do not employ RF energy to jam enemy radar and radio communications, but instead 'listen' to the EM spectrum to detect and locate hostile RF emissions. The detection and location of these emissions then allows electronic attack to be employed.

Finally, Electronic Support Measures [ESMs] 'intercept, identify and locate sources of intentional and unintentional radiated EM energy for threat recognition'.[4] This process is linked to the application of the passive EW techniques discussed above. ESMs are used to gather Electronic Intelligence [ELINT] to establish an electronic order or battle detailing an adversary's radar and radio communication/navigation systems. This is achieved by analysing hostile RF transmission to determine their electronic characteristics and thus distinguish and geo-locate hostile and friendly radar and radio systems. By analysing the electronic characteristics of these hostile systems, it is then possible to utilise active and passive EW techniques for jamming.

It is Bomber Command's EW policies for the employment ECMs to perform SEAD against the *Luftwaffe* IADS which this thesis will examine.[5] EW policy refers to the planning performed by Bomber Command's leadership concerning its EW efforts and the drafting of policies to this end. The thesis will ask whether the Command's EW policies were of a

[4] *Ibid.*
[5] 100 (Special Duties/Bomber Support) Group was originally founded as 100 (Special Duties) Group. Its name was then changed to 100 (Bomber Support) Group. To avoid confusion it shall be henceforth referred to as '100 Group'.

proactive and/or reactive nature, and characterise these policies. A proactive EW policy concerns the employment of EW in an anticipatory or pre-emptive fashion; i.e. expecting the enemy to use particular radar or radio communications/navigation systems, or specific radar or radio communications/navigation techniques, and to devise and execute EW in such a way as to prevent these systems or techniques being effective. Conversely, a reactive EW policy employs electronic warfare in response to specific known radar or radio communications/navigation systems or techniques. In a nutshell, proactive and reactive EW policies take respective preventative and curative approaches.

Bomber Command's EW policies would be implemented via the use of ECMs as part of an overall SEAD effort which the Command pursued during the conflict. The thesis will determine the levels and methods of application by which these ECMs were used against the IADS, and will apply several theoretical models to determine the levels and methods application by which they were brought to bear as a result of the Command's EW policies. EW forms a central component of the SEAD mission.[6] This is not surprising given that the employment of radar and radio communications/navigation systems are essential to the functioning of an IADS. Although described in more detail in the following chapter, SEAD can be executed at the Campaign, Localised and Opportune levels.

Broadly speaking, Campaign suppression has a theatre-wide remit to perform the wholesale suppression of all elements of a hostile IADS as and when they are discovered prior to and during a specific operation with the intention of causing a theatre-wide long-term degradation of an IADS. Localised suppression works to disrupt, degrade and/or destroy a hostile IADS

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[6] J.C. Rentfrow, *Electronic Combat Support for an Expeditionary Air Force: The Lessons of History, Wright Flyer Paper No.15* (Maxwell Air Force Base, Alabama: Air Command and Staff College, 2001), p.2.

either in its entirety, or in a piecemeal fashion, across a specific geographically-defined area over a specific timeframe. Finally Opportune suppression is restricted to self defence against, and attacks on, elements of a hostile IADS as and when they appear either as a primary or secondary target during a specific mission.[7]

Campaign, Localised and Opportune levels of SEAD can be applied using Manoeuvre, Stealth/Surprise, Mass and Balance (a combination of Stealth/Surprise and Mass) methods. The Manoeuvrist approach employs surprise, deception and acting more rapidly than one's adversary, while also exploiting weak points in the IADS to determine and use as comparatively lower risk routes for aircraft/strike package ingress and egress.[8] The Stealth/Surprise approach utilises airframe design techniques to reduce an aircraft's visibility to radar and/or specific flight profiles to achieve the same effect. For the purpose of this study this approach will include EW tactics or techniques developed to reduce an adversary's radar detection range.[9] The Mass approach to SEAD uses large numbers of aircraft and/or ECMs to saturate a hostile IADS at a particular point to overwhelm it. Meanwhile the Balanced approach combines Stealth/Surprise and Mass to initially punch a hole in a hostile IADS, and then employ Mass to exploit the breach and perform additional attacks against the IADS to progressively overwhelm it.[10]

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[7] D. Baltrusaitis, *Quest for The High Ground: The Development of SEAD Strategy, A Thesis Presented to the Faculty of the School of Advanced Airpower Studies for the Completion of Graduation Requirements* (Maxwell Air Force Base, Alabama: School of Advanced Air Power Studies, Air University, 1997), p.3.

[8] C. Bellamy, 'Manoeuvre Warfare' in R. Holmes, ed. , *The Oxford Companion to Military History* (Oxford: Oxford University Press, 2001), p.541 and S.J. Dougherty, *Defense Suppression: Building Some Operational Concepts: Thesis Presented to the Faculty of the School of Advanced Air Power Studies, Maxwell Air Force Base, Alabama for Completion of Graduation Requirements Academic Year 1991-92* (Maxwell Air Force Base, Alabama: Air University Press, May 1992), p.25.

[9] Dougherty, *Defense Suppression*, p.26.

[10] *Ibid.*, p.27.

The Necessity of Examination

The Command's EW policies and subsequent SEAD posture during the Second World War remain under-explored by historians, despite the significant body of work examining Bomber Command. This dearth of examination *vis-à-vis* the Command's EW policies and SEAD posture neglects a significant aspect of its wartime experience. In essence, we know much about the feats of the squadrons, aircrew and aircraft of Bomber Command, but we know comparatively little about how its leadership waged the battle against the *Luftwaffe* IADS.

By answering the thesis' question it will be possible to understand whether the Command pioneered the practice of airborne EW and SEAD which has been, and remains, a vital component of air operations since the end of the Second World War. Post-1945 EW and SEAD have been extensively employed in successive conflicts notably before and during the Arab-Israeli Six Day War in 1967 and Yom Kippur War of 1973, throughout the United States' military involvement in the Vietnam War between 1965 and 1975, and in the 1991 Gulf War and the 2003 invasion of Iraq. EW and SEAD were also used during the North Atlantic Treaty Organisation interventions in the Balkans in 1995 and 1999; and in Libya in 2011.

General non-academic works examining the EW efforts of the RAF during the Second World War have been written by Crowther and Whiddington, Howard, Jones, Macksey, Pritchard and Rankin.[11] However, the EW activities of Bomber Command are not examined in any detail in Crowther and Whiddington's *Science at War.* The Command's EW efforts are

[11] J.G. Crowther, R. Whiddington, *Science at War* (New York: Philosopher's Library, 1947), M. Howard, *Strategic Deception in the Second World War* (London: WW Norton and Company, 1995); R. Jones, *Most Secret War: British Scientific Intelligence 1939-1945* (London: Penguin, 2009 [1979]); K. Macksey, *The Searchers: Radio Intercept in Two World Wars* (London: Cassell, 2003) and N. Rankin, *Churchill's Wizards: The British Genius for Deception 1914-1945* (London: Faber and Faber, 2008).

similarly largely ignored in Howard's *Strategic Deception in the Second World War* as they are in Rankin's *Churchill's Wizards: The British Genius for Deception 1914-1945* and Mackesy's *The Searchers: Radio Intercept in Two World Wars*.

There is a modest body of mainly non-academic published work which examines Bomber Command's EW efforts during the Second World War. Some of these books are relatively detailed although largely descriptive, providing a narrative account of the Command's work and largely focusing on the tactical execution of the its EW efforts, through discussions of the actions of individual squadrons or aircraft types, or through the articulation of anecdotes from the Command's veteran air and ground crews. For example, Devereux's work is largely a technical history of radar and radio innovation in the military context written for the layperson with a workmanlike discussion of the Command's electronic warfare endeavours.[12] Furthermore, Pritchard's work is a largely anecdotal account of German radar development during the Second World War. Likewise, Cordingly's book is essentially a *memoir* of the author regarding his training and night flying career prior to his involvement in Bomber Command's EW work.[13] Meanwhile, although Jones wrote one of the seminal books examining electronic warfare writ large during the Second World War, his discussion of Bomber Command's efforts to this end are arguably sparse compared to those of other authors included in the canon of literature.

One of the most recent examinations of the Command's EW efforts occurred on 10 April 2002 when the Royal Air Force Historical Society hosted a conference discussing EW in the RAF, publishing the proceedings in its journal. Four papers examined the RAF's experience

[12] T. Devereux, *Messenger Gods of Battle: Radio, Radar, Sonar: The Story of Electronics in War* (London : Brassey's, 1991).
[13] N. Cordingly, *From a Cat's Whisker Beginning* (Braunton: Merlin Books, 1988).

with electronic warfare during the Second World War. Price presented a paper entitled 'A New Look at the "Wizard War"' which concerned itself with articulating the ways and means by which the RAF jammed *Luftwaffe* radio navigation transmissions intended to assist its bombers locating targets in the United Kingdom.[14] Such a subject is beyond the scope of this thesis. This is not the case though for Air Vice Marshal Jack Furner's paper '100 Group – Confound and …'. Furner had served with 214 Squadron, an EW unit which was itself a constituent part of Bomber Command's 100 Group raised in November 1943 to wage EW and kinetic warfare against the *Luftwaffe* IADS. The author detailed the ECMs used by the Group, and Bomber Command in general, to jam *Luftwaffe* radar and radio communications. Like other writers examined below, Furner included a discussion of the use of the Window ECM, deployed from July 1943, to jam *Luftwaffe* Telefunken FuMG-62D *Würzburg* Fire Control/Ground Controlled Interception [FC/GCI] radars, briefly summing up the debates within the RAF and Air Ministry regarding the use of this ECM, lest it trigger a jamming war with the *Luftwaffe* responding in kind against RAF ground-based air surveillance radars. Like other writers whom have examined Bomber Command's EW efforts, Furner argued that Window was successful in reducing Command losses for a limited time, although evaluating the success, or otherwise, of the Window ECM is also beyond the scope of this thesis. Furner provided a list of 100 Group's terms of reference upon its activation, as do other writers whom have examined the Command's EW work. The author added details as to why the Boeing B-17 Flying Fortress heavy bomber was chosen to equip 100 Group's 214 Squadron as an electronic warfare aircraft, outlining the ECMs which equipped this platform. Furner detailed his personal experience as a 214 Squadron aircrew member during the night of 5/6 June 1944 when the unit was tasked with performing EW in support of the Operation

[14] A. Price, 'A New Look at the "Wizard War"', *Royal Air Force Historical Society Journal*, 28 (2003), p.15.

Overlord amphibious and airborne landings in France. He also provided a short discussion of jamming activities performed by other parts of the Group, particularly the use of the Mandrel ECM directed against *Luftwaffe* ground-based air surveillance radar and the use of Window. Furner continued his discussion by detailing the ECMs which the Command applied against the IADS following Overlord, as Bomber Command continued its strategic air campaign against Germany notably Mandrel, Window, Carpet (also directed against FC/GCI radars), Piperack (used to jam *Luftwaffe* AI radar) and the trio of Tinsel, Jostle and Airborne Cigar [ABC]; all of which were used to jam *Luftwaffe* radio communications. Furner concluded his discussion by arguing that the Group's activities, and the Command's EW efforts in general were significant in reducing the number of aircraft losses had these measures not been available.[15]

The third paper to be presented during the conference was '100 Group Fighter Operations' by Streetly; an author whose other work is examined elsewhere in this introduction.[16] Nonetheless, as his paper was exclusively concerned with fighter operations, and hence the largely kinetic aspects of the Command's SEAD efforts, as opposed to its EW work, it receives no further examination. Much like Furner, Price discussed Bomber Command's EW efforts during Overlord in his paper 'D-Day and After'. Price reiterated the application of Window to jam *Luftwaffe* radar, while chronicling the impact that such ECMs reportedly had on *Luftwaffe* radar operators. Price supplemented this discussion with examples of how the Command would later use ECMs in support of other operations later in the war.[17] While the discussions of Price *et al* at this conference were instructive, they were primarily focused on the tactical aspects of Bomber Command's EW efforts against the *Luftwaffe* IADS, and

[15] J. Furner, '100 Group – Confound and … ', *Royal Air Force Historical Society Journal*, 28 (2003), pp.24-31.
[16] M. Streetly, '100 Group Fighter Operations', *Royal Air Force Historical Society Journal*, 28 (2003).
[17] A. Price, 'D-Day and After', *Royal Air Force Historical Society Journal*, 28 (2003), pp.45-50.

contained no discussion of the wider intentions of Bomber Command's leadership regarding EW policies, and their desired effects on the IADS.

The Existing Literature

Following the thesis' first chapter detailing the theoretical models to be applied to Bomber Command's EW policies and SEAD posture, the second and third chapters will examine the Command's EW policies and SEAD posture between September 1939 and December 1941, and between January 1942 and July 1943 respectively. The thesis will state that Bomber Command was essentially bereft of either an EW policy or resulting SEAD posture for much of this period, and it would not be until October 1942 that the Command would implement its first EW policies and commence the deployment of ECMs *en masse*. As such, the existing literature largely ignores this period of the Command's history *vis-à-vis* its attitudes towards EW.

Nevertheless, some authors do examine the impact that Bomber Command's operations during the two years of the war would have on its eventual implementation of EW policies. For example, Stubbington argued that the commencement of the RAF's strategic air campaign against targets in Germany and occupied Europe from May 1940 was instrumental in prompting the adoption of ECMs by the RAF to reduce losses.[18] His position was echoed by Bond and Forder whom cited analysis performed by the Command in August 1942 which claimed that loss rates could be reduced by up to 60 percent with the introduction of ECMs, noting that a recommendation was made by Bomber Command in October 1942 that

[18] J. Stubbington, *Bletchley Park Air Section Signals Intelligence Support to RAF Bomber Command* (Alton: Minerva Associates, 2010), p.16.

electronic countermeasures be employed against FuMG-62D radar and Gema FuMG-80 *Freya* ground-based air surveillance radar. The installation of ECMs bought a distinct challenge, the authors argued, in terms of aircraft payload: The installation of ECMs inevitably came at the expense of available bomb load and work load, as aircrew were needed to operate this equipment during demanding phases of their missions when they were delivering ordnance against their targets.[19]

Streetly has arguably written the most comprehensive account of the Command's EW activities during the Second World War; and his work examined the factors underpinning the formation of 100 Group. He took the position that initially Bomber Command rejected the employment of ECMs as they contravened its policy of maintaining radio silence when over enemy territory. Streetly argued that it was left to Fighter Command, tasked with defending the United Kingdom, to embrace ECMs, particularly Moonshine, to support its Circus operations. Commencing in 1942, Circus operations involved a formation of fighters escorting a smaller formation of bombers over occupied territory with the intention of forcing the *Luftwaffe* into battle. During such operations, Moonshine was used to jam the *Luftwaffe's* FuMG-80 radars by creating the appearance of an approach of a large formation of bombers to persuade the *Luftwaffe* that Bomber Command was performing an attack, and to tempt them to scramble their fighters. The author claimed that, despite the acceptance of ECMs by Fighter Command, Bomber Command continued to resist their employment into 1942. This, he argued, was because the Command was anxious not to employ ECMs against the *Luftwaffe* lest the *Luftwaffe* respond in kind and jam the RAF's Chain Home ground-based air

[19] S. Bond, R. Forder, *Special Ops. Liberators: 223 (Bomber Support) Squadron, 100 Group and the Electronic War* (London: Grub Street, 2011, Kindle Edition), p.12.

surveillance radars which were intrinsic to providing Fighter Command with advanced warning of incoming *Luftwaffe* aircraft.[20]

Streetly stated that Bomber Command's policy was eventually forced to change in 1942 following the so-called 'Channel Dash' when the *Kriegsmarine* (German Navy) 'Scharnhorst' class battleships *Scharnhorst* and *Gneisenau* departed the port of Brest on the French Atlantic coast on 11 February *en route* to their home port of Wilhelmshaven on the German North Sea coast. Known as Operation Cerberus to the *Kriegsmarine*, the Channel Dash was notably achieved with the successful employment of ECMs directed against British radar to prevent the detection of the ships as they passed through the English Channel. Streetly argued that the *Kriegsmarine's* use of ECMs against British radar removed any doubts of the RAF and British defence scientific community regarding Germany's ECM capabilities. He posited that this would become an important motivation in eventually encouraging Bomber Command to protect its aircraft with ECMs.[21]

An additional factor which helped propel the adoption of ECMs by the Command, Streetly continued, was the use of Identification Friend or Foe [IFF] transponders in Bomber Command aircraft against FuMG-62D radars.[22] Streetly stated that from early 1942 Bomber Command crews activated their IFF equipment believing that it could douse *Luftwaffe* FuMG-62D radar-controlled searchlights despite Bomber Command's official opposition to the use of ECMs. He added that there was no evidence that this employment of IFF equipment had any such effect on the searchlights. Streetly continued that the use of the IFF sets in this

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[20] M. Streetly, *Confound and Destroy: 100 Group and the Bomber Support Campaign* (London: MacDonald and Jane's, 1978), p.15, p.17.
[21] *Ibid.*, p.160.
[22] *Radio Identification Systems: Identification, Friend or Foe or IFF* http://www.qsl.net/vk2dym/radio/iff.htm (Accessed 7 November 2014)

fashion was to have serious consequences for Bomber Command losses by providing an RF transmission which the *Luftwaffe* could use to detect and locate the transmitting aircraft.[23] The IFF's utilisation, Streetly argued, directly ended the Command's policy of radio silence and effectively marked its commencement of ECM use against the *Luftwaffe's* IADS.

Although the canon of literature provided a cursory examination as to why Bomber Command would eventually adopt ECMs, it failed to state how the Command was minded to implement these. The authors do not state whether ECMs were to be used only to protect Bomber Command aircraft during their missions over Germany or to whether they were part of a wider undertaking to cause the wholesale destruction of the *Luftwaffe* IADS, or both? While stating that EW policies were reactive at this point in the war, for example the IFF being used as a response to the threat from *Luftwaffe* searchlights, the authors cited do not provide examples of whether EW policies were in any way proactive.

Chapter Four will cover a time period of July to November 1943 and examine the reasons behind Bomber Command's activation of 100 Group. Much of the body of literature covering this timeframe is focused on debating the effectiveness of the Window ECM. Bond and Forder considered the effectiveness of this ECM arguing that its employment degraded the performance of radar-directed Anti-Aircraft Artillery [AAA] as *Luftwaffe* AAA units obtained fire control information from FuMG-62D radars, with the authors making the claim that Window had a 'significant effect' on radar-directed AAA to this end.[24] Streetly also discussed the application of Window, and he argued that despite its initial use during Operation Gomorrah, the week-long bombing of the German city of Hamburg in late July 1943 when it

[23] Streetly, *Confound and Destroy*, p.18.
[24] Bond, Forder, *Special Ops. Liberators*, p.8.

was judged to have been successful in jamming *Luftwaffe* radar, the IADS was capable of neutralising Window's effectiveness, although the ECM would remain a problem for the *Luftwaffe* for the rest of the war.[25] Bowman and Cushing also discussed the efficacy of Window positing that it performed effective jamming of the FuMG-62D radar, along with the Telefunken FuG-202/212/220 *Lichtenstein* range of AI radars equipping *Luftwaffe* fighters. The authors stated that the *Luftwaffe's* adoption of the so-called *Wilde Sau* ('Wild Boar') night fighter tactic devised to outflank Window jamming was a reflection of the ECM's success.[26] The *Wilde Sau* tactic devised in 1943 called for pilots flying Focke-Wulf Fw-190 fighters to detect the silhouette of an enemy aircraft against the residual light provided by the searchlights and fire glow illuminating the sky from a city during an attack by Bomber Command, and by light generated from target marker flares dropped by *Luftwaffe* fighters following the Main Force of bombers.[27] As *Wilde Sau* placed a premium on the visual identification of hostile aircraft, the authors argued that it reduced the *Luftwaffe's* reliance on radar and hence negated the efficacy of Window.[28]

Beyond the discussion of Window, several authors examined the reasons behind the formation of 100 Group. Bowman stated that the high levels of losses experienced by the Command between September and October 1943, particularly during the bombing of Hanover in central Germany when *Luftwaffe* fighters inflicted significant casualties, were motivations for the group's activation.[29] He continued that by the autumn of 1943 losses had reached such critical proportions that the activation of a new group directed against the IADS was deemed

[25] Streetly, *Confound and Destroy*, p.21.
[26] M. Bowman, T. Cushing, *Confounding the Reich: The RAF's Secret War of Electronic Countermeasures in WWII* (Barnsley: Pen and Sword Aviation, 2004), p.12, p.14, p.156.
[27] Streetly, *Confound and Destroy*, p.219.
[28] Bowman, Cushing, *Confounding the Reich*, p.12, p.156.
[29] M. Bowman, *100 Group (Bomber Support): RAF Bomber Command in World War II* (Barnsley: Pen and Sword Aviation, 2006), p.18.

necessary by the Command.[30] Brettingham meanwhile argued that Air Marshal Arthur Harris, who became Bomber Command's Air Officer Commanding-in-Chief [AOC-in-C] in February 1942, had a significant influence on encouraging the Group's establishment. Harris specifically deduced, stated the author, that aircraft losses were increasing throughout 1942 as a result of an increasingly potent *Luftwaffe* IADS in the form of fighters and radar-controlled AAA. Brettingham argued that ECMs, and the activation of a dedicated force within Bomber Command to deploy them, was seen by Harris as an ideal riposte to these threats.[31] Similarly Price, the only author in the canon whom has written about Bomber Command's EW efforts from an academic standpoint, posited that the activation of 100 Group was done for the purpose of protecting Bomber Command aircraft during night operations. He discussed how the Group's aircraft used their ECMs to help protect Bomber Command during operations over Germany.[32] Moreover, Streetly stated that the adoption of fighter tactics by the *Luftwaffe* such as *Zahme Sau* ('Tame Boar') in 1943 was causing Bomber Command to adopt an ever-more complex programme of responses such as false target marking and diversionary raids. *Zahme Sau* was a tactic which required fighters to scramble upon warning of a raid, and to orbit a radio beacon to await vectoring towards the incoming aircraft under direction from fighter controllers on the ground. The fighters would then use their organic AI radar to detect individual bombers to perform their attacks. The advent of *Zahme Sau* would force Bomber Command to adopt diversionary tactics with the intention of keeping the fighters away from their aircraft. These factors Streetly believed, prompted Bomber Command to contemplate 'the creation of a specialised organisation to handle both RCM and spoof operations'.[33] That

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[30] *Ibid.*
[31] L. Brettingham, *Even When the Sparrows are Walking: The Origin and Effect of No. 100 (Bomber Support) Group, RAF, 1943-45* (Kinloss: Librario Publishing, 2002), p.15-16.
[32] A. Price, *Instruments of Darkness: The History of Electronic Warfare 1939-1945* (London: Greenhill Books, 2005 [1967]), p.227, p.228, pp.229-230.
[33] Streetly, *Confound and Destroy*, p.31.

‘specialised organisation’ would become 100 Group. Likewise, Stubbington argued that increasing losses played their part in triggering the Group’s formation, stating that as the war continued Bomber Command sustained loss rates of ten percent during some operations. As a consequence Stubbington stated, the *Luftwaffe’s* ground-based air surveillance radar network and radio communications/navigation systems essential fighter control were targeted by the Mandrel and Tinsel ECMs installed on Bomber Command’s aircraft. Stubbington argued that the weight and power demands of these two ECMs had an adverse effect on the range and payload of individual bombers. In tandem with the need for the aircrew to operate these ECMs, and the risk of distraction from their primary mission, these factors encouraged the formation of 100 Group.[34] In Bowman and Cushing’s co-authored work, they expanded arguments regarding Bomber Command losses, stating that the Command needed a long-range force which could provide ECM and fighter protection to the Main Force during operations, with a similar argument echoed by Bond and Forder, whom also stated that the expansion of Bomber Command’s strategic air campaign at this point in the war represented another motivation for the Group’s activation.[35]

Logistical consideration was a further motivation for the Group’s activation, Brettingham argued, notably the need to reduce the weight and power consumption of the ECMs outfitting the Command’s aircraft, via their migration to dedicated electronic warfare platforms.[36] Streetly and Brettingham argued that the burden placed on the Command’s aircraft by these ECMs was expected by its leadership to deepen in the future as the *Luftwaffe’s* IADS increased in lethality and sophistication, further encouraging the establishment of 100

[34] Stubbington, *Bletchley Park Air Section*, p.18, p.19
[35] Bowman, Cushing, *Confounding the Reich*, p.18 and Bond, Forder, *Special Ops. Liberators*, p.4, p.12.
[36] Brettingham, *Even When the Sparrows are Walking*, p.88.

Group.[37] Price argued that this proliferation of ECMs was due to the *Luftwaffe* increasing the waveband of frequencies used by its radars to frustrate the Command's efforts to jam them. Put simply, as the RAF discovered one set of frequencies and began to jam them the German scientific establishment would either change the frequencies of the radars being jammed, or develop and deploy new radars transmitting different frequencies. The challenge for the RAF, Price argued, was the finite amount of space and weight on each bomber to house the requisite number of ECMs capable of detecting and jamming hostile radars. Ultimately, the number of aircraft required to provide sufficient ECM coverage to protect Bomber Command's formations during their attacks became so large that a new RAF unit in the guise of 100 Group had to be established.[38] Brettingham also stated that the logistical challenges caused by the large number of ECMs outfitting aircraft in Bomber Command squadrons prior to the Group's formation was exacting a toll on the RAF's supply organisation. Linked to these considerations, Brettingham continued, was the need to consolidate the Command's EW endeavours into a single unit, reducing demands on bombers, logistics and maintenance services, and demands on the Telecommunications Research Establishment [TRE], the Ministry of Aircraft Production organisation tasked with developing ECMs. Brettingham stated that, as Fighter Command was using ECMs alongside Bomber Command, this caused a duplication of effort in terms of ECM research, development and production, and he argued that the creation of 100 Group was a means by which the number of different RAF organisations demanding *materiel* from the TRE could be reduced.[39]

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[37] *Ibid.* and Streetly, *Confound and Destroy*, p.31.
[38] Price, *Instruments of Darkness*, p.227.
[39] Brettingham, *Even When the Sparrows are Walking*, pp.88-89.

Beyond logistical considerations, Price posited that the Group was activated to gather ELINT regarding the *Luftwaffe* IADS.[40] Furthermore, Stubbington argued that EW efforts made by the RAF prior to the Group's activation were instrumental in its formation, and the author cited the establishment of 80 Wing on 7 October 1940 to employ ECMs during the so-called 'Battle of the Beams' as a key motivation.[41] The Battle of the Beams involved the *Luftwaffe's* use of radio navigation systems such as *Knickebein*, *X-Gerät* and *Y-Gerät* to improve the accuracy of its bombers when attacking targets in the United Kingdom during 'the Blitz' strategic air campaign between 7 September 1940 and 21 May 1941. Part of the RAF's riposte, Bond and Forder noted, was the corresponding employment of ECMs by 80 Wing.[42] On a similar theme, Streetly argued that the navigational accuracy of Bomber Command's aircrews needed to improve in order to ensure that their weapons struck their intended targets in the required concentrations. The navigational aids which were introduced to this end included the GEE radio navigation system which debuted in 1942. GEE utilised HF radio transmissions to guide an aircraft towards its target. The author stated: 'The introduction of navigational aids would inevitably lead to the cherished radio silence (of Bomber Command) being broken, if not by actual transmissions from the aircraft then at least by transmissions to them.'[43]

Despite these arguments, the literature does not provide any discussion regarding the Command's long-term vision for 100 Group. The arguments articulated by the authors stated that the Group was raised as the result of a reactive EW policy, yet they neglect to state whether the Group's activation was also the result of a longer-term desire to degrade the

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[40] A. Price, *The Evolution of Electronic Warfare Equipment and Techniques in the USA, 1901 to 1945* (PhD Thesis, Loughborough University of Technology, 1985), p.203.
[41] Stubbington, *Bletchley Park Air Section*, p.16.
[42] Bond, Forder, *Special Ops. Liberators*, p.5.
[43] Streetly, *Confound and Destroy*, p.17.

potency of the *Luftwaffe* IADS. Moreover, the body of literature gives no meaningful account of the discussions and the decisions made at senior levels of the Air Ministry and Bomber Command concerning the establishment of 100 Group. The literature tells us why the Group was activated, but tells us little of the deliberations at senior levels within these organisations which resulted in its establishment.

Chapter Five of the thesis will examine Bomber Command's EW policies and resulting SEAD posture between November 1943 and May 1944. Price charted the expansion of 100 Group throughout 1944 in terms of aircraft, ECMs and squadrons, along with the effect that the Group's activities had on the *Luftwaffe* in terms of their fighter losses, and the tactics which that force brought to bear against Bomber Command. Reflecting on his discussion of the Group's formation and activities, Price stated that: '100 Group could not claim the sole credit for the sudden decline in Bomber Command's losses from the autumn of 1944, yet the unit's jamming, spoofing and intruding activities undoubtedly helped to ensure that the *Luftwaffe* never recovered from the initial blow.'[44] Despite Price's focus on the Group's formation, activities and successes, he did not discuss the Command's EW policies in this timeframe, which were also neglected in his doctoral thesis entitled *The Evolution of Electronic Warfare Equipment and Techniques in the USA, 1901 to 1945*. As the title suggests Price chiefly focused on the development of EW techniques and ECMs in the United States during the first half of the twentieth century. Nevertheless, his work does contain some discussion of 100 Group. Chiefly the thesis examined the reasons for the Group's establishment, along with its aircraft and ECMs, and the employment and efficacy of those ECMs.[45]

[44] Price, *Instruments of Darkness*, p.229, p.233, p.232.
[45] Price, *The Evolution of Electronic Warfare*.

Regarding Bomber Command's EW efforts during this period of the war, Bond and Forder discussed the activation of 214 Squadron with its Fortress-BII/BIII EW aircraft in January 1944 as part of 100 Group in a bid to jam *Luftwaffe* fighter radio navigation systems, and the trials and tribulations of using this aircraft for EW. Other themes explored by the authors include the activation of the USAAF's [United States Army Air Force] 803 Bombardment Squadron as part of 100 Group's order of battle in April 1944, plus the arrival of the RAF's 199 Squadron into 100 Group the following month. Their work also examined the exploits of 100 Group's 223 Squadron and the Consolidated Liberator-BVI EW/ELINT-gathering aircraft which this unit operated.[46] Bowman echoed Bond and Forder's discussion of the gradual enlargement of 100 Group's order of battle throughout the period under examination, and discussed the arrival of 192 Squadron in the Group. He briefly discussed 214 Squadron's jamming efforts during April 1944 in support of Bomber Command operations against Cologne, western Germany.[47] In Bowman's co-authored volume with Cushing, the two authors examined the enlargement of the Group throughout the first six months of its activities. They discussed squadron operations, and the actions of individual aircrew, which comprised much of their investigation of 100 Group's initial operations. Furthermore, Bowman and Cushing focused on the introduction of the De Havilland Mosquito fighter-bomber into 100 Group service during this timeframe. Other areas explored by the authors included the high level of losses suffered by the Command in the first months of 1944, while also detailing 214 Squadron jamming operations, and the experience of individual aircrew; a theme they also explored regarding 169 Squadron. Some discussion of Bomber Command EW policy was made by both authors, but this did not extend beyond articulating the decision

[46] Bond, Forder, *Special Ops. Liberators*, p.14, p.15.
[47] Bowman, *100 Group (Bomber Support)*, p.20, p.23.

to increase 100 Group EW activities in May 1944.[48] As a consequence of their tactical focus the characteristics of the Command's EW policies were largely ignored. It is noteworthy that Bowman also produced a volume entitled *100 Group (Bomber Support): RAF Bomber Command in World War II*.[49] However this work was a comparatively slimmer volume compared to the book co-written with Cushing. It contained largely the same material as the latter and therefore the arguments conveyed by Bowman in his monograph mirrored those articulated in the co-authored volume.

Much of Brettingham's work focused on the fighter force employed by 100 Group to protect Bomber Command aircraft during sorties over Germany. The author included a brief discussion of the tactics which 100 Group would bring to bear against *Luftwaffe* fighters, and the Group's commencement of Intruder operations to attack *Luftwaffe* airfields and fighters in February 1944. A significant amount of Brettingham's examination of 100 Group during the period under discussion was concentrated on the role of 100 Group as a fighter force, as opposed to its application of EW; the former subject being beyond the scope of this thesis.[50] Like Brettingham, much of Streetly's discussion of Bomber Command EW efforts focused on the air-to-air activities of the Group, although it did include a small discussion of 192 Squadron's ELINT gathering work from February 1944, and the tactics of 214 Squadron. The rest of Streetly's work examining the period of November 1943 to May 1944 focused on the activation of 199 Squadron, and the enlargement of 100 Group's order of battle. Streetly also included a discussion of ELINT gathering by 100 Group aircraft from December 1943, and the activation of 214 Squadron as a dedicated jamming unit.[51]

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[48] Bowman, Cushing, *Confounding the Reich*, pp.18-19, pp.20-27, pp.31-32. p.34, pp.36-39, p.41, pp.44-46.
[49] Bowman, *100 Group (Bomber Support)*, p.20.
[50] Brettingham, *Even When the Sparrows are Walking*, pp.96-98, pp.98-100, pp.106-114.
[51] Streetly, *Confound and Destroy*, pp.39-46.

Harrington's book largely concentrated on the articulation of anecdotal accounts from members of 100 Group, with the discussion of the first six months of the Group's operations limited to a brief descriptive account of the gradual enlargement of its order of battle.[52] Similarly Price examined the enlargement of 100 Group between November 1943 and May 1944, and discussed its adoption of the Fortress-BII/BIII.[53] Nevertheless, as a whole, the canon largely eschewed a discussion of the drafting of Bomber Command's EW policies and how they were enacted via SEAD over this timeframe. As with the discussion regarding the activation of 100 Group during the period under examination, the authors confined themselves to examining the tactical aspects of Bomber Command's EW activities as opposed to decision-making regarding these policies within its leadership.

Chapter Six examines the Command's EW policies and SEAD posture in preparation for, and during Operation Overlord. This operation is examined as the provision of EW to support combined operations was one of the missions 100 Group was earmarked to perform.[54] Overlord would be the only such operation which the Group supported during the war and, as the thesis will illustrate, several 'lessons learned' from this endeavour were then adopted during Bomber Command's EW and SEAD work throughout the rest of the war. The existing literature examined the Command's EW and SEAD activities against the *Luftwaffe* IADS during the operation. For example, Brettingham provided a short discussion of the Command's work in support of Overlord to jam radar and radio communications supporting the IADS. The author gave a brief explanation regarding how the Mandrel ECM was

[52] J. Harrington, *RAF 100 Group: The Birth of Electronic Warfare* (London: Fonthill Media, 2015), pp.14-15, p.27.
[53] Price, *Instruments of Darkness*, pp.227-228.
[54] 'Role and Function of No. 100 (SD) Group, AVM Walmeley, SASO, Bomber Command 21 March 1944', The National Article, AIR 2/7309, Radio Counter-Measure Organisation, Role and Functions of No.100 (SD) Group.

deployed to mask airborne operations from *Luftwaffe* radar via the use of the Mandrel Screen; a tactic devised to shield formations of aircraft from detection by *Luftwaffe* ground-based air surveillance radar. Brettingham did provide a limited discussion of Bomber Command's EW policy, and outlined the thinking of 100 Group's Air Officer Commanding Air Vice-Marshal [AVM] Edward Addison who believed that a key part of the Group's task was the destruction of *Luftwaffe* fighters to prevent them attacking the Main Force. In particular, Brettingham discussed a conference held on 20 May 1944 at Bomber Command headquarters to examine the role of the Group during Operation Overlord *vis-à-vis* the *Luftwaffe* fighter force.[55]

Bowman, meanwhile, gave little more than a cursory discussion of the activities of 100 Group's 85, 157 and 515 Squadrons during the operation; all of which performed air defence and airfield Intruder attacks that do not fall under the focus of this thesis. Bowman's discussion of these three squadrons was reinforced with a short discussion of the Mandrel, Window and ABC ECMs; and their deployment during Overlord.[56]

Compared to the works of Brettingham and Bowman, Price gave a fuller discussion of Bomber Command's EW efforts before and during Overlord. The author outlined the pivotal importance of the operation to the Allies' strategy for defeating Germany, and the importance of a comprehensive EW strategy therein. Price continued by discussing the importance for the success of Overlord inherent in the destruction of *Luftwaffe* radar stations on the Atlantic, English Channel and North Sea coasts of Western Europe to prevent the detection of the airborne and seaborne elements of the invasion fleet. This discussion was reinforced by an explanation of the importance of kinetic and electronic attack to achieve this goal, with

[55] Brettingham, *Even When the Sparrows are Walking*, p.112, p. 123.
[56] Bowman, *100 Group (Bomber Support)*, p.22, p.87.

examples given by the author of kinetic attacks performed by the RAF against *Luftwaffe* ground-based air surveillance radar. This, Price explained, was achieved following the activation of the USAAF's 803 Bombardment Squadron to support the EW effort. In addition, he outlined the use of the ABC ECM and the activities of 101 and 214 Squadrons to create a fake Main Force of bombers as a spoof in areas of France adjacent to where the invasion would occur.[57] Jones and Streetly also discussed the importance attached to defeating *Luftwaffe* radar as part of the RAF's EW efforts prior to Overlord, explaining the tactics that RAF fighter-bombers would employ regarding kinetic attacks against such targets.[58] Similarly Streetly provided a short discussion of Mandrel and ABC ECM operations, and what they were intended to achieve, in particular, stressing the *modus operandi* of the Mandrel Screen.[59]

While there is some discussion of the importance of EW to the overall invasion effort, much of the existing literature's focus was on the kinetic attacks made against *Luftwaffe* radar stations; efforts which did not involve Bomber Command, and are hence beyond the focus of this thesis. Nevertheless, there are notable omissions in the existing literature, such as an examination of the work performed by the ground-based jamming components of Bomber Command therein, notably 80 Wing, which had joined 100 Group in November 1943. Crucially, the existing body of literature fails to discuss the importance of Bomber Command's EW policies and SEAD posture regarding Overlord *vis-à-vis* its activities against the *Luftwaffe* IADS for the rest of the war. As this thesis will state, the Command's activities during the operation were in effect a 'dress rehearsal' for how Bomber Command would fight the *Luftwaffe* IADS for the remainder of the war.

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[57] Price, *Instruments of Darkness*, p.207, p.209, p.214, p.217
[58] Jones, *Most Secret War*, p.400, p.405.
[59] Streetly, *Confound and Destroy*, p.53.

Following the thesis' focus on Overlord, Chapter Seven will examine the Command's EW policies and SEAD posture between May and November 1944. As the title of their work suggests, Bond and Forder concentrated on the activities of the Liberator-BVI heavy bombers converted for EW work which comprised part of 100 Group's order of battle from August 1944, with much of their writing focused on anecdotal accounts of the aircraft from the RAF ground crew and aircrew whom worked with it. The authors provided some limited discussion regarding the use of the Mandrel Screen by 100 Group to protect the Command's aircraft from *Luftwaffe* radar. Another area examined by the two authors was how the Mandrel Screen worked alongside the Special Window Force [SWF] deployed the ECM *en masse* to jam *Luftwaffe* FC/GCI radar during this period.[60] Jones also discussed the workings of the SWF and the effect it had on the *Luftwaffe* IADS fighter component by compelling these aircraft to take off unnecessarily in the mistaken belief that the SWF constituted the Main Force.[61] Streetly continued the discussion of the Mandrel ECM giving a detailed technical description of the workings of the Mandrel Screen with a briefer description of the SWF, and the introduction of the Carpet ECM into 100 Group's 171 Squadron.[62] He continued by arguing that the Group's work between May and November 1944 was characterised by the successful application of jamming *en masse* against the *Luftwaffe* IADS.

Bowman gave a short description of 100 Group activities involving the use of the Jostle and Window ECMs from July 1944, with a similarly small-scale description of the Piperack ECM introduced from October 1944 to jam *Luftwaffe* AI radar. These short discussions included descriptions of how Jostle and Window were employed during this timeframe, in particular the use of Window to support Main Force operations over Germany's Ruhr Valley industrial

[60] Bond, Forder, *Special Ops. Liberators*, p.16, p.30.
[61] Jones, *Most Secret War*, p.467.
[62] Streetly, *Confound and Destroy*, pp.53-56, p.60, p.70, p.74.

heartland from November 1944.[63] Likewise Brettingham discussed some of the activities of the SWF and the adoption of the Jostle ECM, in addition to his short discussion of Piperack.[64] Meanwhile Price focused on the importance of the arrival of a *Luftwaffe* Junkers Ju-88G fighter in the United Kingdom, complete with its FuMG-220 *Lichtenstein* SN-2 AI radar in July 1944 which enabled the TRE to develop an ECM which could be used against this system.[65]

Despite the adoption of the *Wilde Sau* tactic in 1943 Bowman and Cushing claimed that 100 Group's efforts at this point in the war had been successful in reducing Bomber Command losses. They noted that during October 1944 a combination of the Groups' efforts, plus the Allied advance across Western and Northern Europe following Overlord combined to reduce Bomber Command losses.[66] The latter factor had an effect as the more territory which the Allies liberated, particularly in Western Europe, the more of the *Luftwaffe's* IADS spread across Germany's occupied territories fell under Allied control thus taking it out of the air battle. Moreover, this shortened the warning time that the IADS could provide to the *Luftwaffe* to alert ground and air defences to counter incoming Bomber Command attacks. A third factor in degrading the efficacy of the *Luftwaffe's* IADS, Bowman and Cushing argued, was the employment of Intruder patrols which commenced in May 1942 but later fell under 100 Group's purview.[67] However, such kinetic efforts are beyond the focus of this thesis.

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[63] Bowman, *100 Group (Bomber Support)*, p.23, p.24, pp.25-26.
[64] Brettingham, *Even When the Sparrows are Walking*, p.131, pp.135-137.
[65] Price, *Instruments of Darkness*, pp.220-221.
[66] Bowman, Cushing, *Confounding the Reich*, p.140.
[67] *The de Havilland Mosquito as a Night Fighter* http://www.historyofwar.org/articles/battles_mosquito_night_fighter.html (Accessed 24 October 2014)

Nonetheless, the established canon of literature made few references to the decisions taken by Bomber Command's leadership regarding its long-term intentions concerning the destruction of the IADS. Much of the work focused on the exploits of individual ground and aircrew whom supported the Command's EW efforts with a notable focus on 100 Group's kinetic air-to-air efforts. Crucial omissions include any discussion of the importance of Overlord in providing the Command with a template highly relevant to degrading the IADS for the remainder of the war, and how the EW policies and SEAD posture of the Command was, as this thesis will argue, not only to keep Command aircraft losses as low as possible but reflected an aspiration of the Command's leadership to progressively degrade the *Luftwaffe* IADS until such a point where it could no longer meaningfully challenge Bomber Command's operations over Germany.

The final chapter of the thesis examines the Command's EW policy and SEAD posture during the last six months of the war from November 1944 until May 1945. Stubbington made the claim in the forward to Bond and Forder's book that the actions of the Group saved up to 1,000 Bomber Command aircraft. He continued that these efforts caused strain on the German scientific and radio research establishment which was forced to constantly devise tactics and mechanisms to neutralise and/or reverse any advantage won by the Command resulting from ECM employment. As well as causing a strain on the German scientific establishment, Stubbington made the point that 100 Group's efforts adversely impacted the morale of *Luftwaffe's* aircrew and IADS personnel whom had to reckon with the degradation of their tactics and equipment as a result of the Group's activities.[68]

[68] Bond, Forder, *Special Ops. Liberators,* p.1.

In further examining the efficacy of 100 Group's efforts, the authors argued that by 1945 the air component of the *Luftwaffe's* IADS, in particular its fighter force, was beginning to suffer a notable reduction in efficacy. Bond and Forder stated that the employment of Mosquito fighters and fighter-bombers helped to exact a toll on *Luftwaffe* fighters both in terms of air-to-air combat, and through attacks against the airbases used by *Luftwaffe's* night fighters during Intruder operations. The authors made the point that throughout 1945 the *Luftwaffe* continually encountered tactics employed by 100 Group in support of the Main Force which included the use of the SWF to create 'phantom' formations of aircraft on *Luftwaffe* radar screens which would thus force the *Luftwaffe* to spread its fighter resources to meet this threat. Nevertheless, they continued that the introduction of ECMs and tactics to counter the threat posed by the IADS was cyclic and that for every ECM introduced by Bomber Command, the *Luftwaffe* would eventually devise a tactic, or an upgrade to an existing radar or radio system, in an attempt to counter the ECM.[69]

Brettingham's work gave a descriptive account of the Command's operations in protecting the Main Force during the final six months of the war. He discussed the use of Piperack and the continued employment of the SWF in protecting the Main Force. He also discussed the final 100 Group operations of the war, and interspersed this with anecdotes from aircrew who supported these missions.[70] Likewise, Brettingham's examination of 80 Wing's activities supporting Command operations at this point in the war largely comprised anecdotal reflections. This was also the case for Bowman and Cushing's work which was rich in anecdotal accounts of the Group's missions.[71] Meanwhile, Price discussed the enlargement of

[69] *Ibid.*, p.36, p.66.
[70] Brettingham, *Even When the Sparrows are Walking*, pp.137-138, p.140
[71] Bowman, Cushing, *Confounding the Reich*.

100 Group's order of battle from the autumn of 1944, and detailed how the Mandrel Screen and SWF continued to be used to support the Command's operations.[72]

Streetly also focused on the effectiveness of 100 Group's fighters and fighter-bombers. In analysing the overall effectiveness of the Group's efforts, he argued that it was the so-called 'Mosquito Phobia', known to the *Luftwaffe* as *Mosquitopanik*, which defeated its fighters, rather than the overall ECM campaign of the Group as the *Mosquitopanik* saw *Luftwaffe* aircrew taking risks to avoid interception by RAF fighters which correspondingly caused an increase in *Luftwaffe* low flying accidents. Additional accidents were caused, he posited, when night fighters attempted to land at airfields which were unlit so as to avoid attack by the Mosquitoes. Streetly argued that these factors caused a lowering of morale in the *Luftwaffe* fighter force which was increased by a requirement for *Luftwaffe* fighter aircrew to perform night ground attacks against RAF airfields in an attempt to destroy aircraft on the ground or preparing to land. Reflecting on the overall contribution of 100 Group to Bomber Command's campaign Streetly argued that its efforts enabled the Command to incur 'acceptable' losses as opposed to defeating the IADS in its entirety.[73] Like Streetly, Stubbington posited that the presence of the Mosquito caused *Luftwaffe* fighter aircrews to perform 'almost unending evasive manoeuvres' which led to an increase in flying accidents particularly when performing terrain-following flights. Furthermore, Stubbington examined the ELINT gathering efforts of 192 Squadron and the use of Carpet and Piperack at this stage in the war, together with the introduction of the Handley Page Halifax-BIII heavy bomber as an EW aircraft into 100 Group service.[74]

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[72] Price, *Instruments of Darkness*, pp.229-233.
[73] Streetly, *Confound and Destroy*, p.143.
[74] Stubbington, *Bletchley Park Air Section*, pp.28-29, p.39.

Streetly's work provided a brief discussion of 100 Group's EW policy. Summarising the contribution which the Group made in reducing Command losses he posited that Addison prized the application of the offensive against the *Luftwaffe* IADS above all else. Addressing an interview which the author performed with him, Streetly said that the Air Officer Commanding of 100 Group was not especially concerned whether a particular ECM or tactic was effective, but was more interested in keeping the enemy 'on its toes' by 'constantly frightening him and worrying him'.[75]

The established literature argued that Bomber Command's EW efforts were cyclic, and that for every ECM, or EW tactic or technique that was introduced, the *Luftwaffe* would develop a riposte. Arguments were articulated that the actions of the Command, in particular the fighter and fighter-bomber force which was by now accompanying the efforts of the Main Force were also adversely affecting the strength of the *Luftwaffe* fighter force as were the activities of the Mandrel Screen and SWF. Streetly came closest in examining the intentions of Bomber Command's leadership regarding its EW efforts, noting that Addison articulated his intentions to continually attrit the *Luftwaffe* IADS. Yet this was the only discussion of the intentions behind the Command's EW efforts in Streetly's work which did not examine how the intentions of the Command's leadership regarding its EW policies and subsequent SEAD posture developed throughout the entirety of the war, including prior to the establishment of 100 Group. It is these subjects which will fall under the purview of this thesis.

[75] Streetly, *Confound and Destroy*, p.143.

Methodology

The methodology to be employed will include a survey of the secondary sources discussing Bomber Command's EW and SEAD efforts. Primary sources to be consulted will include the official Air Historical Branch narratives examining Bomber Command's strategic air campaign, and the Royal Air Force's use of electronic warfare during the conflict.[76] Bomber Command's squadron histories, diaries, plans, memoranda, papers of key individuals, minutes of meetings and correspondences will be highly relevant to this thesis and sources of such documentation can be found at the United Kingdom's National Archive.

Given that a significant part of this thesis will examine the Command's efforts to jam *Luftwaffe* radar and radio communications it may be essential to seek some additional guidance where the technical comprehension of aspects of these activities are concerned. Therefore it may be necessary to consult materials held by, and members of, specialist electronic warfare organisations such as the Association of Old Crows, and individuals within the defence industry and military specialising in radar and electronic warfare.

While the thesis will cover six years of Bomber Command's electronic warfare work against the *Luftwaffe* IADs, it will obviously leave some areas unexplored due to space and time constraints. First and foremost the thesis does not intend to discuss the technical aspects of the Command's EW endeavours. Some degree of technical explanation may be required to

[76] AIR 41, *The Second World War 1939-1945, Royal Air Force Signals Volume VII, Radio Countermeasures* (London: Air Historical Branch, 1950), AIR 41/40, *RAF Narrative (first draft): The RAF in the Bomber Offensive against Germany: Volume II Restricted Bombing Sept. 1939-May 1941* (London: Air Ministry, 1948), AIR 41/41, *RAF Narrative (first draft): The RAF in Bomber Offensive against Germany: Vol III Area Bombing and Makeshift Force June 1941-Feb. 1942* (London: Air Ministry, 1949), AIR 41/56, *RAF Narrative (first draft): The RAF in the Bombing Offensive Against Germany, Volume VI, the Final Phase, March 1944-May 1945* (London: Air Ministry, 1949), AIR 41/42, *RAF Narrative (First Draft): The RAF in the Bombing Offensive Against Germany: Volume IV: A Period of Expansion and Experiment, March 1942-January 1943* (London: Air Ministry, 1949) and AIR 41/43, RAF Narrative (First Draft): *The RAF in the Bombing Offensive Against Germany: Volume V: The Full Offensive February 1943 to February 1944* (London: Air Ministry, 1949).

explain how ECMs were devised and employed, although it is not the author's intention to provide a detailed technical explanation of these countermeasures: This task is arguably best left to electronic engineers and physicists. Secondly, it is not the intention to discuss the effectiveness of the Command's efforts; this is a major subject in itself which would require significant additional research and statistical analysis to determine. Inevitably some discussion of the success, or otherwise, of certain EW tactics and techniques will occur but it is outside the scope of this study to discuss their respective merits writ large. The existing literature has already attempted such a discussion, and it will be left to other historians to continue the examination of these questions.

CHAPTER ONE

THE THEORETICAL DIMENSIONS OF AIRBORNE ELECTRONIC WARFARE POLICY AND THE SUPPRESSION OF ENEMY AIR DEFENCE MISSION

Introduction

This chapter will examine the theoretical underpinnings of airborne EW policy and the SEAD mission. The purpose of this chapter is to construct theoretical models regarding EW policy and the SEAD mission which can then be used to analyse Bomber Command's efforts to suppress the electronic elements (radar and radio communications/navigation systems) of the *Luftwaffe's* IADS during the Second World War. These theoretical models will be integral to determining whether Bomber Command's EW policies *vis-à-vis* the IADS were reactive and/or proactive during the conflict, and the SEAD posture the Command adopted to enact these policies.

The chapter will explain why this thesis will apply post war air power theory to Bomber Command's EW policies and subsequent SEAD posture. It will then define the composition and tasks of an IADS. Following this discussion, the chapter will examine the specifics of EW in the airborne context and provide theoretical definitions of proactive and reactive EW policies. As the Command's EW policies were enacted via the application of SEAD, the chapter will define the theoretical levels at which SEAD can be performed and its theoretical methods of application, using examples drawn from several air operations which have occurred since the end of the Second World War. Examples of the Command's SEAD levels and methods of application will not be used, as these will be determined later in the thesis.

The Relevance of Contemporary Theory

The definitions of EW policy, and SEAD levels and methods of application, together with the instructive historical examples discussed in this chapter are taken from the post war era. This is because there was scant discussion of EW or SEAD theory in air power theoretical literature published before the end of the Second World War. The reason for this is simple: an IADS with a composition similar to that used by the *Luftwaffe* had not been encountered during air operations before this conflict. Prior to the cessation of the Second World War, air power theorists paid scant attention to the threat posed by Ground-Based Air Defences [GBAD]. Theorists such as Lanchester dismissed the threat that AAA posed to air operations, and noted that: 'All things considered, it would appear probable that attack on aeroplanes at high altitude from the ground will be found impracticable, or at least uneconomical.'[1]

This dismissive reaction was echoed by two of air powers' most important theorists; Giulio Douhet and William Mitchell. Given that aircraft operated in the air, the 'third dimension' as Douhet had termed it, they could effectively access any point on the globe and crucially they could fly over naval and ground forces. As a consequence Douhet believed that surface forces became less able to influence the outcome of a conflict. He believed that defence against aircraft was all but impossible as the defender could never know the exact direction, location or timing of an air attack. Meilinger reflected that Douhet believed GBAD to be a pointless

[1] F.W. Lanchester, *Aircraft in Warfare, The Dawn of the Fourth Arm* (London: Constable and Company, 1916), p.27.

exercise. This was because Douhet argued that AAA was rarely able to successfully hit and destroy an aircraft: 'Douhet sarcastically conceded that ground fire might down some aircraft like muskets shot in the air might occasionally hit a swallow, but it was not a serious deterrent to air attack.'[2] That Douhet made no reference to the necessity to suppress GBAD is perhaps of little surprise: He simply did not believe AAA would have any effect and therefore its suppression would be unnecessary.

Like Douhet, Mitchell dismissed the notion that GBAD could adversely affect an attack against a city from the air, with the only defence against such attack being other aircraft:

> No missile-throwing weapons or any other devices have yet been created or thought of which can actually stop an air attack, so that the only defense (sic) against aircraft are other aircraft … Such a place as New York, for instance, would have to be defended if attacked by hostile bombers, and, as no anti-aircraft guns or other efforts, from the ground alone, would be of any particular avail.[3]

Mitchell was emphatic that GBAD would have no appreciable effect on air operations against strategic targets such as cities. During such an attack he claimed that the expenditure of 'thousands of round' of AAA shells would be wasted. In addition, AAA gunners would become acutely fatigued by their inability to engage hostile aircraft and, if the attack was performed at night, would suffer significant eye strain because of muzzle flash from their weapons. Ultimately, Mitchell stated that: 'The whole arrangement of ground protection against aircraft, sound ranging, searchlights and guns cannot stand up under intelligent air attack and is incapable of serious effect on airplanes.'[4]

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[2] P.S. Meilinger, *Airwar: Theory and Practice* (London: Frank Cass Publishers, 2003, Kindle edition), pp.13-15.
[3] W. Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power Economic and Military* (New York: Dover Publications, 1988 [1925]), pp.8-11.
[4] *Ibid.,* pp.8-11, p.204.

Douhet and Mitchell's sentiments regarding the vulnerability of aircraft to GBAD were partially echoed by William Sherman, a contemporary of Douhet, although he parted company with both theorists regarding the question of SEAD on the battlefield. Like Douhet, Sherman was sceptical of the potential of GBAD to adversely affect the conduct of strategic air operations. He reflected on the experiences of the *Deutsche Luftstreitkräfte* (German Army Air Corps) performing attacks during the First World War on the cities of London and Paris initially using Zeppelin airships and later, from 1916, Gotha heavy bombers. Sherman argued that: 'To guard these capitals against hostile air raids, hundreds of guns and airplanes were installed. Notwithstanding all this array of force … the German airplanes suffered only insignificant losses.'[5]

Although Sherman echoed Douhet's position regarding the potential of GBAD to interfere with the application of air power against strategic targets such as cities, Sherman examined the ability of GBAD to harass 'battlefield' missions such as the provision of Close Air Support [CAS] to troops in contact. Sherman wrote that he considered 'ground strafing' the 'most dangerous mission of all' which a pilot could perform. In particular, he noted that the threat to aircraft came from the machine guns and rifles that troops on the ground had to defend themselves. As regards the threat posed by AAA to aircraft performing CAS, and the battlefield interdiction of key targets such as supply depots, command centres and troop billets behind the front line, Sherman believed that there were steps which could be taken to neutralise the danger posed by the AAA defending such targets. He stated that counter-battery attacks by aircraft could be performed against hostile AAA, arguing that SEAD could be employed to help protect other aircraft performing CAS or battlefield interdiction: 'Attack

[5] W.C. Sherman, *Air Warfare* (Maxwell Air Force Base, Air University Press, 2002 [1926]), pp.27-28.

aviation may be called upon to support combined operations of the air force by counter-battery action against antiaircraft artillery.'[6]

Sherman expanded his thoughts regarding the application of air power to perform SEAD. In speculating on how air power maybe employed in future conflicts, he posited that 'attack aviation', the name he gave to aircraft performing CAS and battlefield interdiction, will have a role:

> (I)n attacking the anti-aircraft defenses (sic), with bomb and bullet. Gun batteries are practically helpless against such attacks, and only the lighter armament (rifles and machine guns) need be feared. At times also, a number of attack airplanes, fitted with the special smoke laying apparatus, will put down a heavy screen to windward of the antiaircraft defences, and so tend to blind them.[7]

Importantly, when envisaging future air operations, and how they could be conducted, Sherman argued that SEAD operations would form a core part of larger combined packages of aircraft which would include bombers striking key targets, and fighters (which he refers to as 'pursuit aviation') cleansing the sky of their enemy counterparts:

> While the experience of the World War shows that antiaircraft fire can never stop a determined force, nevertheless it is undeniable that the effectiveness of bombing raids is increased as hostile antiaircraft units are neutralized. This shows the desirability of synchronizing the operations of bombardment and of attack aviation. In fact, it should be the rule of the air force to fight as a whole, the sweep of pursuit squadrons affording protection from air attack to the other two components alike while attack aviation in its turn, puts down a neutralizing fire on all hostile antiaircraft batteries within range.[8]

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[6] *Ibid.*, p.149, p.154,
[7] *Ibid.,* p.171.
[8] *Ibid.*, p.208.

Furthermore, Sherman did not believe that the design and performance of AAA would remain static looking forward, and believed that it would grow in power and sophistication in the future. As a result of this, he argued that attack aviation would be required to perform SEAD in future air operations:

> It is true that (during the First World War), antiaircraft guns in the front areas were sometimes fired on by artillery counter-battery guns. But those in rear areas, protecting supply establishments and other important points, were safe from this danger, and suffered from air attacks only rarely … (as) there was no systematic counter-battery action, as a definite phase of the normal air attack. These conditions will certainly never continue if antiaircraft artillery grows in power and effectiveness. As a routine thing in air operations, units of attack aviation will be told off to silence antiaircraft batteries.[9]

While Sherman's ideas regarding SEAD are prescient, they are of little relevance to this thesis. Sherman envisaged SEAD being performed on the battlefield in support of CAS, as opposed to its practice in support of attacks against strategic targets: Bomber Command's EW policies and SEAD missions therein were not performed in support of CAS and were confined to supporting strategic and operational efforts.

Furthermore, because of this paucity of discussion regarding SEAD in air power theoretical literature prior to the end of the Second World War, the EW policy and SEAD theory definitions, and empirical examples discussed below have been taken from the post-war era. These have relevance in characterising the proactive and/or reactive nature of Bomber Command's EW policies. This is because the Command's EW efforts were directed against radar and radio communications/navigation systems used by the *Luftwaffe* IADS.

[9] *Ibid.*, p.215.

The fundamentals of technology explains why contemporary EW and SEAD theory is relevant to Bomber Command's EW policies and SEAD posture: Although radar technology has continued to develop in the intervening seven decades since the end of the Second World War, its basic scientific principles have remained the same: Put simply, radars transmit RF energy at the speed of light with the intention of this energy being reflected back to the radar after colliding with an object so as to measure the object's speed, altitude and bearing. In this respect, contemporary radar is unchanged from the radar employed by all belligerents during the Second World War. As the publication *Electronic Warfare* notes: 'Although new equipment and new tactics continue to be developed, the physics of EM [Electro-Magnetic] energy remains constant. This physical constant is the reason basic activities of EW have remained effective despite changes in hardware and tactics.'[10]

IADS Defined

Although the IADS used by countries around the world to protect their airspace is largely a contemporary contrivance, they have their foundation in the Second World War. Contemporary IADS such as the North Atlantic Treaty Organisation's [NATO] Air Command and Control System largely perform the same tasks and use the same tools as those employed during the Second World War such as the RAF's Chain Home IADS. These tasks include the detection by radar of hostile aircraft and their interception either by surface-to-air weapons or by fighters. An IADS connects disparate ground and airborne radars to provide a consolidated Recognised Air Picture [RAP] of a country or area of territory. It provides a means of coordinating and executing a response to real or perceived air threats. Often, although not

[10] Joint Publication 3-13-1 *Electronic Warfare* (Washington DC: United States Department of Defense, 25 January 2007) section I-8.

always, under air force control an IADS will comprise ground-based air surveillance and FC/GCI radars, AAA, and Surface-to-Air Missile [SAM] batteries, together with fighters and their airbases, and the Ground Controlled Interception [GCI] centres which will receive imagery from the radars monitoring that GCI centre's Area of Responsibility [AOR], and from which interceptions of aircraft will be directed. Integral to an IADS are the communications links which enable it to be employed in a coordinated manner. Furthermore, each GCI centre will be connected to a higher echelon of command comprising the IADS headquarters where overall command of each GCI centre is exercised. The headquarters may also federate the RAP generated by each GCI into a single RAP for the nation or territory which it is responsible for defending.[11]

In the context of the Second World War, the *Luftwaffe's* IADS comprised:

(I) Its fighters and their AI radar, the radio communications between fighters and their controllers on the ground; fighter radio navigation systems, such as beacons, and fighter bases.

(II) The *Luftwaffe's* network of ground-based air surveillance radars and FC/GCI radars used for fighter control, and for the direction of AAA and searchlights.

(III) The GCI centres for the fighters, radars, AAA and searchlights plus the communications systems linking these centres to one another, and to their subordinate units.

[11] J. Crabtree, *On Air Defense* (Santa Barbara: Praeger, 1994), p.172.

This thesis will examine how Bomber Command drafted EW policies and directed its SEAD efforts against these constituent electronic elements of the *Luftwaffe* IADS.

SEAD Defined

An IADS threatens air operations given its *raison d'étre* which is to engage hostile aircraft. To minimise, or even eliminate, the threat posed by an IADS it must either be destroyed or suppressed using destructive or disruptive means. These destructive and disruptive means are the two key tenets of the SEAD mission. This is underscored by the RAF *Air and Space Warfare* publication which stressed that; 'SEAD operations are designed to neutralize, destroy or temporarily degrade enemy air defences by destructive or disruptive means.'[12]

In the execution of SEAD, destruction is arguably preferable to suppression as it removes a threat for a prolonged period until its repair or replacement; it is better to destroy a ground-based air surveillance radar than render it temporarily unserviceable. Nevertheless, such a course of action may not always be possible for several reasons: The exact physical location of the radar maybe unknown, making its attack by an air-to-surface weapon difficult if not impossible. Since the end of the Cold War, popular concerns regarding high levels of collateral damage during air operations could mean that rules of engagement may prevent the destruction of such a target should it be located in an urban area in close proximity to civilians, or civilian infrastructure, such as a school or hospital. Finally, the destruction of such a target could overburden available aircraft and air-to-surface weapons more urgently

[12] Air Warfare Centre, *Air and Space Warfare,* section 7-16.

required elsewhere for the engagement of other targets.[13] For these reasons it may be necessary to suppress an IADS threat, rather than destroy it outright.

The suppressive element of SEAD focuses on disruption. Disruption contains five main aspects; denial, degradation, deception, delay and neutralisation. Both active and passive mechanisms can be used for disruptive SEAD.[14] In the active domain this includes the application of electronic attack to temporarily or permanently disrupt the communications and sensors integral to an IADS. Active measures can also include the use of air-to-surface weapons such as Anti-Radiation Missiles [ARMs] employed against ground-based air surveillance and FC/GCI radars, although such weapons were not available to the belligerents during the Second World War as they were not yet invented. An ARM is designed to detect a hostile radar transmission, determine the geographical position of the radar and then use the radar's RF transmission to guide itself towards its target: While this mission has a destructive element, it can be employed in a suppressive fashion: Should a radar detect the ARM, its operators may then stop their radar transmission to break the missile's lock. This is known as the 'switch off' tactic. In such a context the ARM has played a disruptive role; the radar may remain intact as the ARM may lose its lock, yet by switching off, the radar has been disrupted as it has lost the ability to detect aircraft.

Alongside active disruptive measures such as ARMs, passive disruptive measures are bought to bear during SEAD. These can include ECMs such as chaff. Chaff, which remains in use today is the contemporary name for the Window countermeasure. Put simply, chaff is a collective term for thousands of strips of metal foil cut to half the wavelength of the radar they

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[13] *Ibid.* section 7-6.
[14] *Ibid.*

are intended to disrupt. Radar transmissions detect the chaff which reflects these transmissions back to the radar as an echo. As each strip of chaff produces its own echo this inundates the radar operator's screen with thousands of echoes, technically referred to as 'clutter', masking the true echo of an aircraft. Chaff is disruptive as it will only function for as long as it remains floating in the atmosphere and is hence visible to the radar's RF transmissions. It is not intended to cause the destruction of the radar. These twin tasks of disruption and destruction can be realised 'through either physical attack or electronic warfare'.[15] Given the importance that electronics play in an IADS in the form of radar and radio communications/navigation, it is not surprising that EW has a major role to play in destroying and disrupting these elements during the execution of SEAD.

Electronic Warfare Policy

The EW component of SEAD is applied as the result of EW policy. As discussed above, *Air and Space Warfare* defined EW as 'any military action that involves the use or control of the EM spectrum to reduce or prevent hostile use or to attack the enemy'. The publication continued that, in the air domain: 'EW is used to enhance the survivability of aircraft and ground assets.'[16] For the purpose of this discussion, EW policy refers to the creation and planning of EW provision at the operational level of war for its subsequent application through SEAD at the tactical level.

EW comprises three elements; Electronic Attack [EA], Electronic Protection [EP] and Electronic Support [ES]. EA uses RF energy to 'attack personnel, facilities or equipment with

[15] J.C. Rentfrow, *Electronic Combat Support for an Expeditionary Air Force,* p.2.
[16] Air Warfare Centre, *Air and Space Warfare,* section 10-23

the intent of degrading, neutralizing (sic) or destroying combat capability'.[17] EA also includes activities performed to stop or degrade the hostile use of the electromagnetic spectrum. This can be performed in both a destructive and disruptive fashion using active and passive techniques. An example of a destructive EA approach would be the employment of an ECM such as a jammer which works to transmit levels of RF energy to a hostile radar with the intention of causing permanent or temporary damage. Meanwhile, a disruptive EA approach could include the use of chaff.

Electronic protection 'involves all actions taken to protect personnel, facilities and equipment from any effects of friendly or enemy employment of EW that degrade, neutralise or destroy friendly combat capability'.[18] EP is focused on the development and application of so-called 'Electronic Counter-Countermeasures' [ECCMs], the electronic enhancement of *materiel* to render an ECM ineffective.

Electronic Support forms the third part of the EW triad. It is performed to 'intercept, identify and locate sources of intentional and unintentional radiated electromagnetic energy for threat recognition'.[19] ES focuses on the collection of ELINT. ELINT gathering collects details regarding the RF emissions of friendly and hostile radars so as to build an electronic Order of Battle [ORBAT]. The electronic ORBAT 'details all known combinations of emitters and platforms in a particular Area of Responsibility' and compiling the electronic ORBAT focuses on gathering ELINT concerning the nomenclature, location and function of these

[17] *Ibid.*
[18] *Ibid.*
[19] *Ibid.*

emitters and platforms.[20] By gathering ELINT and compiling the electronic ORBAT it is then possible to apply EP and EA either in support of SEAD or as part of a wider air campaign.

At the tactical level EW can be applied, via SEAD, in both a proactive and reactive fashion, according to the focus of the EW policy. In the SEAD context, proactive EW seeks to implement destructive and disruptive measures against a hostile IADS in a pre-emptive fashion before a particular electronic element of an IADS is deployed and hence becomes a threat, such as a new radar or radio communications system. For example, defence electronics manufacturers continue to configure their designs of ECMs in anticipation of future evolutions in radar technology. This includes the upgrade of existing ECMs, and the design of new airborne ECMs configured to counter the radar threats which armed forces expect to encounter during future air operations.[21]

Reactive EW seeks to destroy and disrupt either all, or parts, of an IADS known to have been deployed. Examples of reactive EW were seen during the United States-led Operation Desert Storm air campaign in 1991. Waged as part of the combined military campaign to oust Iraqi forces from Kuwait, which the former had invaded and occupied in August 1990, the air campaign included a major EW component. Crucial to this were the United States Air Force [USAF] General Dynamics EF-111A Raven, and United States Navy [USN] and US Marine Corps [USMC] Grumman EA-6B Prowler EW aircraft. These were used to jam Iraqi radars

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[20] B. Horne, *Visualising the Electronic Order of Battle* (Fort Belvoir, Virginia: Defence Technical Information Centre, 2002) and ‘Electronic Order of Battle’, https://www.militaryperiscope.com/terms/t0000121.html (Accessed: 6 March 2015).

[21] Confidential interview with a defence industry source at the 2017 Electronic Warfare Conference held in London between 6 June and 8 June 2017.

before and during attacks by other aircraft.[22] Thus they were deployed as a reaction to the existence of Iraqi radars, and to prevent them from detecting coalition aircraft.

SEAD Approaches

As noted above when directed against an IADS, reactive and proactive EW policies are enacted via the application of SEAD.[23] The American air power theorist John A. Warden provided a robust discussion of SEAD theory. He stated that SEAD can be an essential pre-requisite for the establishment of air superiority, noting that: 'Suppression of air and ground-based defenses (sic) may be necessary before attacking systems supporting offensive air.'[24]

Warden continued that an IADS should be neutralised if it renders air operations either impossible or too dangerous. This neutralisation can be achieved, Warden recommended, through the application of EW, the disruption of an IADS' C2 [Command and Control] system and isolating the IADS from its supporting logistics. Warden recommended exploiting weaknesses in the construction and disposition of an IADS, stressing that 'it is rarely equally strong throughout its width and depth'. These weaknesses, Warden posited, can be exploited: '(An IADS') characteristics suggest campaigns against the system based on flank attacks, penetration and exploitation, or systematic reduction from front to rear.'[25]

Baltrusaitis expanded Warden's *modus operandi* for SEAD in terms of flank attacks, penetration, exploitation and systematic reduction, and discussed how they could be executed

[22] S. Morse, ed. , *Gulf Air War Debrief* (London: Aerospace Publishing, 1991), p.104.
[23] For the purpose of this discussion, the term SEAD will be understood to include both destructive and disruptive approaches.
[24] J.A. Warden, *The Air Campaign: Planning for Combat* (Washington DC: National Defense University, 1988), p.26.
[25] *Ibid.* p.36.

at different levels of war. Although Baltrusaitis' work took the form of a thesis presented to fulfil academic commitments at the USAF's School of Advanced Air Power Studies, alongside Dougherty's work noted below (also an academic thesis) both remain arguably the most detailed theoretical frameworks defining SEAD approaches yet written.[26]

Baltrusaitis noted that SEAD can be performed at the Campaign, Localised and Opportune levels, while Dougherty stated that SEAD can be applied using the Manoeuvre, Stealth/Surprise, Mass and Balance approaches.

Campaign SEAD

Baltrusaitis stated that Campaign level SEAD creates 'increasingly favorable conditions for friendly operations by disabling enemy air defence systems, producing long-term theater (sic) wide effects'.[27] In using the Campaign approach SEAD efforts are commenced prior to, and during, a specific operation to progressively disrupt, degrade and destroy an adversary's IADS across the entirety, or across a large proportion of, the theatre of operations.

There are two notable examples of Campaign SEAD: The first was witnessed during the Six Day War fought between Israel and Egypt, Iraq, Jordan and Syria in June 1967. On 5 June, the IAF [Israeli Air Force] launched a major air offensive against the United Arab Republic Air Forces [UARAF] of Egypt, Syria and Jordan.[28] A major component of Israel's air offensive was the attack of Egyptian, Jordanian and Syrian ground-based air surveillance

[26] Baltrusaitis, *Quest for The High Ground*, and Dougherty, *Defense Suppression.*
[27] Baltrusaitis, *Quest for The High Ground*, p.3.
[28] 'The Six Day War June 1967' in C. Bishop, S. Moeng, S, *The Aerospace Encyclopedia of Air Warfare: Volume Two: 1945 to the present* (London: Aerospace Publishing, 1997), p.158.

radars which formed part of these countries' respective IADS.[29] Alongside kinetic attacks against the radar, the IAF employed a number of tactics to disrupt, degrade and destroy the Egyptian IADS during the conflict. These included:

> C-47 transports (flying) back and forth along the Israeli/Egyptian frontier, dispensing chaff. Other electronic countermeasures also were employed to disrupt Egyptian radar and radio communications and to deny electronic intelligence to the many other forces monitoring the Middle East.[30]

The IAF's persistence in continuing attacks against the IADS of Egypt, Jordan and Syria adhered to Baltrusaitis' definition of Campaign SEAD as the IAF worked to create 'increasingly favorable conditions for friendly operations by disabling enemy air defences.' The IAF's efforts against the respective IADS greatly assisted its destruction of the UARAF on the ground, hence created 'long-term theater (sic) wide effects'[31] preventing the UARAF from ever meaningfully challenging IAF air supremacy, or interfering with Israeli Army operations on the ground.

The second notable example of Campaign SEAD was witnessed during the Operation Allied Force air campaign mounted by NATO in 1999 to expel the forces of the Republic of Serbia from the province of Kosovo, and to stop the ethnic cleansing of Kosovar Albanians. The air campaign included a Campaign SEAD component. At the core of this was the need to neutralise as much of Serbia's IADS as possible. A particular emphasis was placed on the destruction and disruption of approximately 16 S-125 Neva target tracking and fire control radars accompanying Serbian SA-3 medium-range SAM batteries, and 25 IS91 fire control

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[29] K.S. Brower, S.L. Canby, M. Van Creveld, *Air Power and Maneuver Warfare* (Maxwell Air Force Base, Alabama: Air University Press, 1994), pp.164-165.
[30] L. Nordeen, *Fighters over Israel* (London: Guild Publishing, 1991), p.71.
[31] Baltrusaitis, *Quest for The High Ground*, p.3.

radars accompanying the 2K12 ‘Kub’ mobile medium-range SAM system. This was in addition to a number of longer-range ground-based air surveillance radars designed to warn Serbian air defenders of incoming formations of NATO aircraft.[32]

NATO’s approach to the disruption and destruction of the Serbian IADS focused on the deployment of a large SEAD force. This included 48 USAF General Dynamics F-16CJ Block-50 and 30, and USN and USMC EA-6B Prowler SEAD/EW aircraft. These were both equipped to deploy Texas Instruments/Raytheon AGM-88 High-Speed Anti-Radiation Missiles designed to home in on hostile radar transmissions. This was in addition to Panavia Tornado-ECR combat aircraft from the *Luftwaffe* and *Aeronautica Militaire* (Italian Air Force) carrying the same weapon, while RAF Tornado-GR4 aircraft also carried an anti-radar weapon in the form of the British Aerospace Air-Launched Anti-Radiation Missile. Addition support was given by USAF Lockheed EC-130H Compass Call aircraft to disrupt IADS radio communications, while USAF Boeing RC-135V/W Rivet Joint aircraft monitored the success of the kinetic and EW attacks in suppressing the Serbian IADS. The size and scope of the Campaign SEAD component of Allied Force was illustrated by the fact that 743 ARMs were fired against the radars supporting the Serbian IADS during the conflict. The IADS itself achieved over 800 SAM firings against NATO aircraft, 466 of which included radar-guided SA-6 SAMs.[33]

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[32] B. Lambeth, ‘Kosovo and the Continuing SEAD Challenge’, in *Aerospace Power Journal* (Maxwell Air Force Base, Alabama: Air University Press, Summer 2002).
[33] *Ibid.*

Localised SEAD

While Campaign SEAD is designed to have theatre-wide effects, Localised SEAD has 'specified time and space limitations (and) supports specific operations or missions'.[34] Examples of Localised SEAD occurred during the Korean War of June 1950 to July 1953. As Hone noted, the Korean War included SEAD efforts performed by United Nations forces, notably the USAF and USMC. These efforts principally focused on the execution of Localised suppression. For example, in late 1951 and early 1952, the USMC commenced suppression measures against hostile AAA. These assumed Localised suppression characteristics, as noted by Werrell who stated that USMC aircraft would attack known North Korean AAA positions 30 seconds before ground attack aircraft would commence their bombing run. Variations of this approach involved the attack of known AAA positions with artillery fire prior to the ground attack aircraft's arrival.[35] During the conflict, examples of localised suppression were witnessed during sorties by strategic bombers against North Korean targets, where chaff was dispersed to protect USAF Strategic Air Command Boeing B-29D/B-50 Superfortress strategic bombers from 1951.[36] Hone argued that USAF SEAD efforts during the Korean War were primarily predicated on protecting individual aircraft or formations during particular sorties, as such, they fall squarely within the Localised SEAD definition.

Following its involvement in the Korean War, the next major deployment for US forces, and the next major application of SEAD occurred during the United States involvement in the Vietnam War from 1965. US air operations commenced that same year, with aircrews from

[34] Baltrusaitis, *Quest for The High Ground,* p. 3 and Joint Publication 3-01.4, *JTTP For Joint Suppression of Enemy Air Defenses (J-SEAD)* section III-5.
[35] K.P. Werrell, *Archie, Flak, AAA, and SAM* (Honolulu: University Press of the Pacific, 2002), p.78, p.80.
[36] T.C. Hone, 'Korea', in B.F. Cooling, ed. , *Case Studies in the Achievement of Air Superiority* (Washington DC: Center for Air Force History, 1994), p.481.

the USAF, USN and USMC facing *en masse* for the first time a new threat in the form of radar-guided SAMs which were supplied to North Vietnam by the Soviet Union and used to protect key targets against air attack, such as Hanoi, the capital of North Vietnam. Hitherto, the primary ground-to-air threat against combat aircraft in warfare had been from AAA. The USAF lost its first aircraft to a SAM on 24 July 1965, when a McDonnell Douglas F-4C Phantom fighter-bomber was shot down by a Soviet-supplied North Vietnamese SA-2 Guideline high-altitude SAM. The loss of the F-4C in July 1965 heralded a steady increase in the proliferation of SA-2s and the number of attacks that they would perform.[37]

US SEAD efforts were initially applied at the Localised level, focusing on protecting aircraft for the duration of their sorties. Initially, from April 1965, this concentrated on the deployment of Douglas EB-66B/C/E ELINT aircraft which were tasked with employing their ECMs to jam North Vietnamese ground-based air surveillance radars to mask the approach of incoming F-4Cs tasked with attacking targets in North Vietnam.[38] This was achieved through a process known as 'Spot Jamming'; where the power output of an ECM is concentrated across a relatively narrow bandwidth corresponding to the bandwidth of the targeted radar.[39]

Activated from November 1965, the 'Wild Weasel-I' initiative was a USAF attempt to reduce the losses sustained by aircraft during their execution of air-to-ground attacks against targets in North Vietnam. The scheme involved USAF North American F-100F Super Sabre fighters equipped with a radar homing and warning receiver to detect emissions from the target

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[37] Werrell, *Archie, Flak, AAA, and SAM,* p.103, p.107.
[38] Hone, 'Southeast Asia', p.526.
[39] 'Chapter 11 Countermeasures', http://www.fas.org/man/dod-101/navy/docs/fun/part11.htm (Accessed: 23 May 2015).

acquisition and fire control radars used by North Vietnamese SAM battalions.[40] These F-100Fs would be accompanied by USAF Republic F-105D combat aircraft using conventional air-to-ground ordnance to attack the SAM sites and accompanying radars: The logic was for the F-100F aircraft to detect the North Vietnamese' SNR-75 radar and hence an SA-2 battalion's location. The F-105Ds would then attack the site. The Wild Weasel-1 effort had the characteristics of Localised SEAD as the attacks against the North Vietnamese SAM battalions were intended to suppress the SAM sites for the duration of an attack against a nearby target so as to protect the main strike package of aircraft.[41]

Another example of Localised SEAD which occurred during the US involvement in Vietnam was the Linebacker-II series of air strikes which US forces commenced on 18 December 1972. The objectives of the air campaign was threefold: To illustrate to the government of South Vietnam that the United States remained committed in its support, to persuade the government of North Vietnam to continue peace negotiations and to pave the way for the eventual disengagement of US forces from the conflict.[42] The earlier Linebacker-I air campaign commenced on 10 May 1972 with the aim of destroying North Vietnam's war-making potential through attacks against stockpiles of *materiel* and on supply lines from North Vietnam to Viet Cong insurgents operating in South Vietnam. Linebacker-II commenced following the breakdown of peace negotiations in Paris. Targets to be struck during the Linebacker-II offensive included military aim points located in and around Hanoi and the port of Haiphong.[43] Accompanying the air strikes on such targets was a concerted SEAD effort performed by USAF, USN and USMC aircraft. This effort took the form of

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[40] 'North American F-100F Super Sabre', http://www.joebaugher.com/usaf_fighters/f100_8.html (Accessed: 23 May 2014).
[41] Werrell, *Archie, Flak, AAA, and SAM,* p.109.
[42] Dougherty, *Defense Suppression,* pp.11-12.
[43] 'Vietnam: Linebacker I and II' in Bishop, Moeng, *The Aerospace Encyclopedia of Air Warfare,* p.127.

Localised SEAD as it focused on protecting bombers, primarily Boeing B-52D/G Stratofortress strategic bombers deployed by USAF Strategic Air Command. Dougherty observed that:

> Twenty to 60 minutes before the first B-52 wave crossed the target, Air Force, Navy, and Marine fighter-bombers attacked airfields and known AAA and SAM sites. About five minutes prior to the raid, F-105 Wild Weasels flew into the target area to suppress the remaining radar-guided ground defences. F-4 fighter bombers sowed protective chaff corridors and EB-66s, EA-3s, and EA-6s emitted ECM jamming signals to help hide the penetrating force. Additional F-4s provided escort and combat air patrol for the strike package.[44]

Opportune SEAD

Finally, Baltrusaitis stated that: 'Opportune suppression includes self-defense and offensive attacks against enemy air defense (sic) targets of opportunity.'[45] Similarly, *Air and Space Warfare* specified that Opportune SEAD is usually 'unplanned and includes aircrew self-defence and attack against targets of opportunity'.[46] Opportune Suppression will not necessarily have theatre-wide (Campaign SEAD) or localised effects and will chiefly be performed to suppress any IADS targets of opportunity which may be discovered during the execution of another sortie. An example of this could include a combat aircraft being tasked to attack a barracks, but detecting a hostile radar or SAM battery during the sortie and attacking this target as well. Alternatively, combat aircraft may patrol a given area with no briefed IADS targets, and only attack such targets as and when they are discovered.

Examples of Opportune SEAD were witnessed during the War of Attrition involving Israel and Egypt which commenced on 1 July 1967, following the conclusion of the Six Day War on

[44] Dougherty, *Defense Suppression,* p.12.
[45] Baltrusaitis, *Quest for The High Ground,* p.3.
[46] Air Warfare Centre, *Air and Space Warfare,* section 7-7.

10 June 1967. During the War of Attrition, which would continue until August 1970 when a ceasefire was agreed between the two countries, the IAF would strike Egyptian IADS targets as and when they were discovered as targets of opportunity.[47] Examples of Opportune SEAD also occurred during the US involvement in Vietnam. Along with performing Localised suppression during a strike package's attacks, Wild Weasel aircraft were tasked to perform Opportune SEAD. So-called 'Hunter-Killer' missions took the form of two-aircraft or four-aircraft formations (or a single aircraft at night) flying to an assigned area and attacking hostile air defences as and when they were detected.[48]

It is important to note that secondary effects may be observed during the execution of Localised and Opportune Suppression that may have an impact at the Campaign level. For example, a package of SEAD aircraft performing Localised suppression may destroy a C2 centre which forms a vital node in an IADS, causing theatre-wide effects if that IADS as a whole can no longer function properly following the loss of such an installation. Similarly, such a target may be hit during Opportune suppression sorties having the same effect.

Applying SEAD

SEAD at the Campaign, Localised and Opportune levels can be applied using the four distinct approaches defined by Dougherty; Manoeuvre, Stealth/Surprise, Mass and Balance (a mix of Stealth/Surprise and Mass). Like Baltrusaitis' work, Dougherty's thesis retained some highly relevant theories regarding SEAD application.

[47] Bishop, Moeng, *The Aerospace Encyclopedia of Air Warfare,* page 150.
[48] A.M. Thornborough, F.B., Mormillo, *Iron Hand: Smashing the Enemy's Air Defences* (Sparkford: Patrick Stephens Ltd, 2002), pp.61-62.

As its name suggests, the Manoeuvre approach applied Manoeuvrist thinking, itself defined by Bellamy as the utilisation of; ‘surprise, deception and being able to act faster than the enemy can respond’.[49] Dougherty’s Manoeuvrist approach to SEAD had two key dimensions: The first was the utilisation of timely intelligence to create a detailed map of an enemy’s IADS and its capabilities. This is necessary as: ‘IADS normally are finite with flanks, have a directional orientation, and are rarely strong in both depth and width – several preferred routes of penetration should be evident’.[50] Once these preferred routes of ingress are identified by determining the gaps and weak points of an IADS, the second dimension of Dougherty’s Manoeuvre approach can be bought to bear. This exploits these preferred routes of penetration for the ingress and egress of combat aircraft to and from their targets to avoid, or to drastically reduce, the danger of attack from hostile IADS.

Operation Eldorado Canyon, mounted by the USAF and USN 15 April 1986, provides an instructive example of the Manoeuvrist approach. This operation included a series of air strikes in Libya directed against the regime of the country’s leader Colonel Muammar Gaddafi, accused by US President Ronald Reagan of sponsoring terrorism. A significant SEAD component accompanied this operation. The first element of Dougherty’s Manoeuvrist approach stressed the utilisation of timely intelligence to create a detailed map of a hostile IADS. Brungess stated that this was done through the extensive use of computer simulations at the mission planning stage. These simulations ‘were developed to show the best routes to fly to evade the detection and lethal envelopes of Libyan air defences’.[51]

[49] Bellamy, ‘Manoeuvre Warfare’, p.541.
[50] Dougherty, *Defense Suppression,* p.25.
[51] J. Brungess, *Setting the Context: Suppression of Enemy Air Defenses and Joint War Fighting in an Uncertain World* (Maxwell Air Force Base, Alabama: Air University Press, June 1994), pp.25-26.

The second tenet of Dougherty's Manoeuvrist SEAD approach focused on the exploitation of gaps and weaknesses identified through the intelligence-gathering process for the ingress and egress of combat aircraft. For example, one of the tactics utilised by the USAF aircraft participating in the raid was the adoption of close formation flying with their accompanying tankers. Stanik noted that this was intended to exploit weaknesses in Libyan ground-based air surveillance radars which may not have been suitably calibrated to discriminate the smaller General Dynamics F-111F Aardvark tactical bombers and EF-111A aircraft from the larger McDonnell Douglas KC-10A and Boeing KC-135R tankers: 'The Air Force hoped that the strike force would appear to unsuspecting radar operators along the route simply as an unarmed flight of Air Force tankers.'[52]

Stealth/Surprise

Dougherty's Stealth/Surprise approach is intended to exploit specific elements of aircraft design or specific flight profiles to mask an aircraft from enemy radar. Radar has weaknesses such as the detection of targets with a low Radar Cross Section [RCS]. A low RCS can be produced for an aircraft by either making it physically small in size, or by utilising design techniques which reduce the quantity of RF energy reflected by the target back to the radar as an echo. The reduction of RF energy reflected to the radar's antenna artificially reduces the aircraft's size as it appears to the radar. Such design characteristics have a key role to play in the Stealth/Surprise approach as: 'A small RCS combined with speed reduces the effective range of an adversary's defenses (sic) to the point where they are essentially nullified.'[53] For

[52] J.T. Stanik, *El Dorado Canyon: Reagan's Undeclared War with Qaddafi* (Annapolis: US Naval Institute Press, 2002), pp.177-178.
[53] Dougherty, *Defense Suppression,* p.26.

the purpose of this thesis, the Stealth/Surprise approach will also include EW tactics or techniques developed to reduce the range of an adversary's air defences, notably their radar.

Examples of the employment of the Stealth/Surprise approach can be seen during Operation Desert Storm; the air component of which commenced on 17 January 1991. It utilised the Stealth/Surprise approach from the outset. At the core of this effort was the employment of USAF Lockheed F-117A Nighthawk ground attack aircraft. The F-117A was designed to present a low RCS. It achieved this by employing an airframe utilising sharp angles and flat surfaces to dissipate RF transmissions when they hit the aircraft, reducing the energy returned to the radar and thus reducing the aircraft's size as perceived by the radar. The design of the aircraft enabled it to penetrate 'the massed defenses (sic) of an estimated 3,000 AAA pieces, and 60 SAM sites', defending the Iraqi capital Baghdad.[54] The first target for the F-117As was the Iraqi Air Force IADS C2 centre at Nukhayb located west of Baghdad close to the Saudi border a few moments after Task Force Normandy (*see below*) had completed its work.[55] With the Nukhayb C2 centre destroyed, a significant portion of the Iraqi Air Force's Central Air Defence Sector, which included Baghdad, was blinded.

Mass

Dougherty's third approach to SEAD employed Mass. Broadly speaking while the Stealth/Surprise approach emphasised the use of aircraft and weapons with a low RCS, the employment of Mass; 'relies on a large number of aircraft to saturate and overwhelm an air defense (sic) system at a given point'. As with the application of SEAD using the

[54] Morse, *Gulf Air War Debrief*, p.53.
[55] Thornborough, Mormillo, *Iron Hand,* pp.200-201.

Stealth/Surprise approach, this thesis will extend Dougherty's definition of the Mass application of SEAD to include EW tactics and techniques which 'saturate and/or overwhelm air defence systems at a given point'. The aim of applying Mass at a given point, Dougherty argued, was to present the defender with a dilemma chiefly whether to defend vital strategic points essential for the conduct of the war, or instead to spread their defences thinly in the hope of defending as much of their territory and war-making potential as possible.[56] By concentrating defences around particular strategic targets, the defender leaves other areas of airspace open or at the very least lightly defended, allowing this airspace to be exploited by the attacker, as lightly defended areas are comparatively easy to attack:

> Such a 'thin' defense (sic) is susceptible to a mass simultaneous attack because airpower can concentrate in time and space to overwhelm it. The mass attack concept will not eliminate attrition to attacking aircraft, but it should lower the percentage of aircraft lost, since the defender cannot engage all of the attackers.[57]

An example of the Mass application of SEAD was witnessed at the start of the Desert Storm air campaign to create gaps in Iraqi IADS coverage, prior to the attacks performed by the F-117As discussed above. The application of Mass SEAD was facilitated via the deployment of Task Force Normandy; a package of US Army McDonnell Douglas AH-64A Apache attack helicopters and two USAF Sikorsky MH-53J special operations helicopters acting as pathfinders. These aircraft attacked an Iraqi Air Force facility equipped with ground-based air surveillance and FC/GCI radars. The aim was to blind a large segment of Iraqi airspace, in which USAF EF-111A aircraft could then orbit to provide additional radar jamming to protect F-117A aircraft which then bombed the Iraqi Air Force IADS C2 centre at Nukhayb. The Task Force Normandy attacks, coupled with the destruction of the Nukhayb facility, resulted

[56] Dougherty, *Defense Suppression,* pp.26-27.
[57] *Ibid.*

in the inability of the Iraqi Air Force's Central Air Defence Sector to generate a RAP of its AOR.[58]

This lack of radar coverage and the inability of the IADS to effectively engage the American aircraft enabled USAF McDonnell Douglas F-15E Strike Eagle ground attack aircraft to strike other elements of the Iraqi IADS. The net effect of these attacks, Thornborough and Mormillo noted, was that by dawn on 18 January 1991, Iraq's regional air defences had been isolated from Baghdad.[59] The application of the Task Force Normandy package; the EF-111A aircraft and the employment of the F-117A aircraft to punch a hole through the Iraqi IADS to enable a larger force of aircraft to then systematically destroy the Iraqi IADS was a textbook utilisation of Dougherty's Mass approach: 'These attacks … paralyzed Iraqi air defences (sic) and permitted waves of non-stealthy aircraft to strike with high effectiveness and very low losses.'[60]

Balance

Dougherty's fourth method of SEAD application is Balance which combines Stealth/Surprise and Mass. This approach employs an initial attack utilising Stealth/Surprise on a hostile IADS with a view to puncturing a hole in overall IADS coverage: 'Stealth attacks on early warning radar and air defense C3 [Command, Control and Communications] nodes 'paralyzes' the enemy's ground-based air defenses (sic) and prevents a timely defensive response.'[61]

[58] Thornborough, Mormillo, *Iron Hand,* pp.200-201.
[59] *Ibid.* p.202.
[60] Dougherty, *Defense Suppression,* p.17.
[61] *Ibid.,* p.25.

Once this gap in the IADS coverage is achieved Mass can be bought to bear with aircraft exploiting the gap as an ingress and egress route with a view to performing Mass SEAD attacks on the rest of the hostile IADS to disrupt; degrade and destroy as much of it as possible. Dougherty advised that: 'To exacerbate this vulnerable situation, non-stealth aircraft should attack in mass to saturate and overwhelm, the degraded air defense (sic) system.'[62]

Israel's 1982 Operation Peace for Galilee is an instructive example of the application of Balance to SEAD. This operation included offensive action which commenced against the Syrian IADS established in the Bekaa Valley, in eastern Lebanon on 7 June 1982. These defences had been deployed to protect Syrian ground troops fighting Israeli forces as a result of the Lebanese Civil War.[63] The application of Balanced SEAD was witnessed by the use of Stealth/Surprise (*see above*) through the employment of IAF Unmanned Aerial Vehicles [UAVs] intended to mimic incoming packages of IAF strike aircraft to fool Syrian radar operators into believing that an attack was taking place.[64] The employment of these UAVs had two effects: The first was to cause the Syrian IADS to launch SAMs against the UAVs believing them to be combat aircraft. As Brungess noted, the use of the UAVs had a simple motivation: '(F)ill the sky with drones, force the enemy to expend all SAMs, and while the adversary is reloading attack in force from an unexpected direction.'[65] The second effect of the employment of the UAVs was to cause the radar component of the Syrian IADS to detect and track the UAVs. This allowed an IAF Boeing 707 Re'em ELINT aircraft to record the behaviour of the Syrian radars and then to initiate jamming efforts against them.[66]

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[62] *Ibid.,* p.27.
[63] Nordeen, *Fighters over Israel*, p.170.
[64] Thornborough, Mormillo, *Iron Hand*, p.190.
[65] Brungess, *Setting the Context*, p.21.
[66] Thornborough, Mormillo, *Iron Hand*, p.190.

The Syrian attacks on the IAF UAVs caused the air defenders to expend a considerable quantity of their SAMs, forcing them to reload once the UAVs had performed their mission. The IAF took advantage of this respite by employing jamming to mask the approach of incoming packages of combat aircraft tasked with attacking the IADS. Mass was applied at this stage with IAF F-4Es equipped with General Dynamics AGM-78 Standard ARMs and Hughes AGM-65 Maverick air-to-ground missiles to engage Syrian IADS targets. A second wave of combat aircraft followed these, commencing attacks on surviving IADS targets using laser-guided bombs and unguided ordnance.[67] The Israeli Army was also involved in this effort firing short-range surface-to-surface missiles against Syrian IADS in the Bekaa Valley.[68] This Balanced application of SEAD, using Stealth/Surprise in the form of the UAV sorties, then Mass in the form of air attacks by the IAF and missile attacks by the Israeli Army resulted in the destruction of all Syrian SAM sites in the Bekaa Valley by 10 June.

It is important to note that the SEAD applications and approaches discussed above are neither absolute nor exclusive. Air operations will not necessarily confine themselves to using one SEAD application. For example, the air component of Desert Storm included the application of Stealth/Surprise with the use of F-117A aircraft and their accompanying low RCS to penetrate and attack elements of the Iraqi IADS. Similarly, the same campaign also included the application of Mass SEAD when the Task Force Normandy helicopter strike package was used to attack a single point in the Iraqi IADS to cause a breach through which other aircraft could fly to attack additional IADS targets. Although characterised as the Mass application of SEAD in this chapter, the SEAD effort on the first night of Desert Storm also arguably employed the Balanced application of Stealth/Surprise and Mass.

[67] *Ibid.*
[68] 'The Six Day War June 1967' in Bishop, Moeng, *The Aerospace Encyclopedia of Air Warfare*, p.179.

Similarly, distinct approaches to SEAD can be used during the same air campaign. Examples of this were witnessed during the involvement of the United States in the Vietnam War. In this context, Localised suppression was employed from 1965 by the USAF and USN to protect packages of aircraft engaging specific targets. The same conflict also saw the employment of 'Hunter-Killer' Wild Weasel missions to perform Opportune suppression, attacking elements of the North Vietnamese IADS as and when they were detected.

Finally, SEAD applications and approaches converge and mix. Israeli efforts during Operation Peace for Galilee are indicative of this. As the discussion above states, this operation witnessed the application of Balanced SEAD through the employment of Stealth/Surprise via the use of UAVs, and the employment of Mass via the use of F-4Es, and other IAF combat aircraft attacking the Syrian IADS with both ARMs and conventional ordnance. This application of Balanced SEAD was performed at the Campaign level. As Brungess stated: 'The destruction of the (Syrian IADS in the Bekaa Valley) was the goal; a significant part of the Israeli military apparatus was mobilized for the SEAD effort as an integral facet of the war.'[69]

The Localised suppression approach can also be performed using Mass SEAD. The discussion above of the Linebacker-II offensive by the USAF, USN and USMC is indicative of this. The SEAD element included USAF F-105G Wild Weasel plus USN and USMC Douglas A-4E Skyhawk and Grumman A-6A Intruder air defence suppression aircraft equipped with ARMs. These aircraft were joined by USAF EB-66C/Es and USN EA-6Bs.

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[69] Brungess, *Setting the Context*, p.17.

This Massed application of SEAD was used for Localised suppression, namely to protect B-52G/H bombers attacking military targets around Hanoi and Haiphong.[70]

A third example of this application/approach mix was witnessed during the involvement of the RAF in the 1982 Falklands Conflict. Part of the British response to the Argentine invasion of the Falkland Islands on 2 April 1982 included a series of long-range air attacks against selected Argentine military targets on the islands codenamed Operation Black Buck. This initiative included seven separate sorties flown by RAF Avro Vulcan-B2 strategic bombers employing a variety of ordnance. Two of the Black Buck missions, notably Black Buck-5 and Black Buck-6, were directed against Argentine GBAD positioned on the islands. Black Buck-5 was mounted on 31 May to attack the main Westinghouse AN/TPS-43F ground-based air surveillance radar believed to be located at Sapper Hill to the south of the island's capital Port Stanley on East Falkland.[71] This radar had a 173 nautical mile/nm (321 kilometre/km) range, and thus the ability to detect and track air targets across a substantial part of the theatre of operations, and to coordinate *Fuerza Aérea Argentina* [FAA/Argentine Air Force] movements.[72] AGM-45A Shrike ARMs were to be launched by a Vulcan-B2 against this radar. The Vulcan-B2 which flew from Ascension Island in the South Atlantic Ocean utilised a combination of low-level flying and radio silence to maintain surprise.[73] There is some debate as to whether Black Buck-5 was successful in damaging the radar sufficiently to render it unserviceable for the remainder of the conflict.[74]

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[70] 'Falklands First Strikes' in Bishop, Moeng, *The Aerospace Encyclopedia of Air Warfare*, p.128.
[71] A. Brookes, *Vulcan Units of the Cold War* (Oxford: Osprey Publishing, 2009), p.79.
[72] R. Higham, S.J. Harris, *Why Air Forces Fail: The Anatomy of Defeat* (Lexington, Kentucky: University Press of Kentucky, 2006), p.247.
[73] Brookes, *Vulcan Units of the Cold War,* p.79.
[74] *Ibid.*, p.79 and T.C. Van Hare, 'Black Buck 7' http://fly.historicwings.com/2013/06/black-buck/ (Accessed: 3 April 2015).

Similarly Black Buck-6, which was mounted on 3 June had the same objective; to destroy the AN/TPS-43F radar which was still believed to be located on Sapper Hill, but which had in fact been redeployed to the west of Port Stanley. Once again, a Vulcan-B2 armed with AGM-45A Shrike ARMs would utilise low-level flight to avoid radar detection and to cause surprise, although on this occasion the mission would be unsuccessful in locating the AN/TPS-43F. That said, Black Buck-6 did succeed in destroying a Skyguard short-range fire control radar accompanying a GADA-601 AAA system operated by the FAA.[75] Thus, the utilisation of the Stealth/Surprise approach was successful in applying Campaign level SEAD as the destruction of the AN/TPS-43F radar would have had theatre-wide effects by depriving the FAA of a significant part of their RAP of the Falklands theatre of operations.

The Necessity of Analysis

The employment of EW forms the central component of Bomber Command's SEAD efforts against the *Luftwaffe* IADS during the Second World War. The SEAD levels and methods of application discussed above include the use of ARMs and conventional ordnance against IADS targets in addition to EW. Despite the Command not employing ARMs, which had yet to be invented, and the examination of the employment of kinetic means against the IADS by the Command, or any other RAF units, being outside the scope of this thesis, the SEAD levels and methods of application discussed here are highly relevant. This is because by using them it will be possible to determine the proactive and/or reactive nature of the Command's EW policies, and the SEAD levels and methods of application by which they were enacted.

[75] Brookes, *Vulcan Units of the Cold War,* p.80.

CHAPTER TWO

BOMBER COMMAND ELECTRONIC WARFARE POLICY AND SUBSEQUENT SUPPRESSION OF ENEMY AIR DEFENCE POSTURE: SEPTEMBER 1939 TO DECEMBER 1941

Introduction

While Chapter One examined the theoretical dimensions of EW policy and the SEAD mission, this chapter will examine the evolution of Bomber Command's EW policy and subsequent SEAD posture from September 1939, when the Second World War in Europe commenced, until December 1941 prior to the Washington/ARCADIA Conference of January 1942. It will initially discuss Bomber Command's offensive posture upon, and immediately following, the outbreak of war; the aircraft and aircrew loss rates sustained during the first six months of hostilities, and the Command's attitude towards the *Luftwaffe's* IADS at this stage in the conflict. The chapter will then discuss the impact of the German invasion of Norway, France and the Low Countries on the Command's efforts to reduce the IADS' effectiveness, noting that the first six months of the war were hallmarked by the constant change of Bomber Command's targeting priorities as reacted to the rapidly changing nature of the conflict. As the chapter will observe, the intensification of the Command's attacks against German strategic targets caused a corresponding intensification of the IADS with the resulting development of the Kammhuber Line. Moreover, while the Command had not commenced efforts against the electronic elements (radar and radio communications/navigation) of the IADS at this point in the war, the RAF did commence Offensive Counter Air [OCA] operations to degrade *Luftwaffe* fighter strength. OCA operations are defined as those intended to 'destroy, disrupt or confine enemy air power as close to its bases as possible'.[1] While it would not be until October 1942 that the Command would start to develop coherent EW policies and SEAD postures, this marked an important point in the Command's efforts to reduce the power of the IADS. Lastly, the chapter will argue that, in the face of mounting losses, the Command became increasingly open to the adoption of ECMs to help protect its aircraft during the latter half of 1941.

September 1939 - March 1940: Acquiring the Knowledge

Bomber Command commenced the Second World War with strict criteria regarding the targets that it could, and could not, attack. As Overy observed, the British government had stated that it would comply with the Hague Rules of Air Warfare which were drafted between 1922 and 1923, but never ratified by its signatories.[2] These rules stated that, where aerial bombardment was concerned: 'for the purpose of terrorizing the civilian population, of destroying or damaging private property not of a military character, or of injuring non-combatants is prohibited'.[3] The rules continued that: 'Aerial bombardment is legitimate only when directed at a military objective, that is to say, an object of which the destruction or injury would constitute a distinct military advantage to the belligerent', and that:

[1] Air Staff, *British Air and Space Power Doctrine: AP3000* (London: Ministry of Defence, 2009), 3.13.7.
[2] R.J. Overy, *The Bombing War: Europe 1939-1945* (London: Penguin Books, 2013, Kindle edition).
[3] 'The Hague Rules of Air Warfare' @https://wwi.lib.byu.edu/index.php/The_Hague_Rules_of_Air_Warfare (Accessed: 13 June 2017).

> Such bombardment is legitimate only when directed exclusively at the following objectives: military forces; military works; military establishments or depots; factories constituting important and well-known centres engaged in the manufacture of arms, ammunition, or distinctively military supplies; lines of communication or transportation used for military purposes.[4]

Alongside the British government's decision to abide by the Hague Rules the United Kingdom, alongside its French ally and German adversary were under pressure from the then neutral United States to refrain from attacking targets where civilians risked becoming casualties. A statement drafted by President Franklin D. Roosevelt on 1 September 1939, the day of the outbreak of the Second World War in Europe, after Germany's invasion of Poland, called upon all of the belligerents: 'to affirm (their) determination that (their) armed forces shall in no event, and under no circumstances, undertake the bombardment from the air of civilian populations or of unfortified cities'.[5] France and the UK responded to Roosevelt's request immediately in the affirmative with Germany providing a similar assurance on 18 September 1939 as its campaign in Poland was reaching its conclusion.[6]

Despite the self-imposed restrictions placed on the Command by the Hague Rules, and the assurances provided to Roosevelt by the British government, Bomber Command did commence operations over Germany, although initially dropping nothing more lethal than propaganda leaflets from 4 September 1939.[7] Nonetheless Bomber Command was not prohibited from performing offensive action. The Anglo-French Declaration on the Conduct of Warfare, published on 3 September 1939 limited air bombardment to military targets,

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[4] *Ibid.*
[5] 'An Appeal to Great Britain, France, Italy, Germany and Poland to Refrain from Air Bombing of Civilians', 1st September 1939 @http://www.presidency.ucsb.edu/ws/?pid=15797 (Accessed: 25 May 2017).
[6] 'British Reply to US President's Appeal on Bombing, 1st September 1939', AIR 41/40, *RAF Narrative (first draft): The RAF in the Bomber Offensive against Germany: Volume II Restricted Bombing Sept. 1939-May 1941* (London: Air Ministry, 1948), Appendix A2.
[7] T. Davis-Biddle, *Rhetoric and Reality in Air Warfare: The Revolution of British and American Ideas About Strategic Bombing* (Princeton: Princeton University Press, 2002, Kindle edition), p.184.

principally warships and attendant naval vessels in port or underway, naval dockyards and naval shore establishments such as barracks and storage facilities; army units, fortifications, barracks, camps, depots, billets, dumps and 'other establishments manned by military personnel', air forces, military aerodromes and air force installations such as depots, barracks and storage facilities, and other facilities manned by air force personnel and finally transportation targets such as troop transport ships in port or underway; roads, canals and railways used for military communications, with the exception of railway stations and trains, roads and inland waterways 'which can reasonably be presumed to be of a military character'.[8] Excluded from these targets were factories and bulk stocks of fuel, other than those supplying deployed forces or in military bases.[9] Further examination of these targets by the British government in 1939 reduced the list of strategically useful and politically permissible targets down to two; the *Kriegsmarine* (German Navy) Schillig Roads naval anchorage north of the German city of Wilhelmshaven on the North Sea, and *Kriegsmarine* ships underway.[10]

Although the British government had restricted Bomber Command to naval targets, alongside the dispersal of propaganda leaflets the Air Staff, the senior officers commanding the RAF were, in September 1939, already examining the wider application of Bomber Command against targets in Germany, and in support of any ground offensive which Germany should commence against Western Europe.[11] Upon the outbreak of war, Bomber Command's order of battle included the aircraft types depicted in figure I:

[8] AIR 41/40, pp.33-34.
[9] *Ibid.*
[10] *Ibid.*, p.36.
[11] *Ibid.*

Figure I - Bomber Command Aircraft Types September 1939

Aircraft	**Type**
Fairey Battle-BI/II/V	Light Bomber
Bristol Blenheim-BI	Light Bomber
Vickers Wellington-BIC/II	Medium Bomber
Handley Page Hampden-BI	Medium Bomber
Armstrong Whitworth Whitley-BIV/V	Heavy Bomber

Source – 'Appendix 38, Bomber Command Orders of Battle: 1939, 1943 and 1945' in N. Frankland, C. Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Volume IV, Annexes and Appendices* (Uckfield: Naval and Military Press, 2006 [1961]), pp.400-402.

The Air Staff envisaged larger aircraft such as the Wellington-BIC/II and Hampden-BI being employed to attack targets in Germany east of the Rhine River, with lighter aircraft such as the Battle-BI/II/V and Blenheim-BI earmarked for CAS and interdiction should Germany commence a ground offensive in Western Europe.[12] As the official account of the RAF's strategic air campaign noted, this placed the RAF at odds with their French allies. Air Marshal [AM] Arthur Barrett, RAF liaison officer to the *Armée de l'Air* (French Air Force), and AOC-in-C of British Air Forces in France, noted that the French military were opposed to any extension of Bomber Command's efforts to military targets east of the Rhine which constituted part of the Franco-German border, until Germany commenced offensive action against Western Europe. The official RAF narrative argued that this difference in Anglo-French intentions 'could not be reconciled'.[13]

[12] *Ibid.*
[13] *Ibid.*, pp.36-37, p.37.

Figure II – Bomber Command Losses for Sorties Despatched: September 1939 - March 1940

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Sep-39	Night	83	5	6.0%
	Day	40	12	30.0%
	Total	**123**	**17**	**13.8%**
Oct-39	Night	32	4	12.5%
	Day	0	0	0.0%
	Total	**32**	**4**	**12.5%**
Nov-39	Night	15	1	6.7%
	Day	4	0	0.0%
	Total	**19**	**1**	**5.3%**
Dec-39	Night	40	0	0.0%
	Day	119	19	16.0%
	Total	**159**	**19**	**11.9%**
Jan-40	Night	38	0	0.0%
	Day	6	0	0.0%
	Total	**44**	**0**	**0.0%**
Feb-40	Night	54	3	5.6%
	Day	4	0	0.0%
	Total	**58**	**3**	**5.2%**
Mar-40	Night	239	11	4.6%
	Day	53	1	1.9%
	Total	**292**	**12**	**4.1%**

Source - 'Appendix 10, Monthly Annual and Grand Totals of Bomber Command Aircraft despatched, missing and damaged on operations September 1939 to May 1945' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Nevertheless, as Overy noted, the restrictions of Bomber Command to the dispersal of leaflets and the attack of naval targets took its toll in aircrew and aircraft. Of all sorties despatched (day and night) during September 1939, which totalled 123 sorties, Bomber Command suffered 17 aircraft missing or crashed; a loss rate of 13.4 percent of sorties despatched (see figure II).[14] Observing the loss rates suffered by the Command during the first month of the

[14] 'Appendix 10, Monthly Annual and Grand Totals of Bomber Command Aircraft despatched, missing and damaged on operations September 1939 to May 1945' in N. Frankland, C. Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Volume IV, Annexes and Appendices* (Uckfield: Naval and Military Press, 2006 [1961]), pp. 431-436.

war, Overy stated that 'even these limited operations brought insupportable casualty rates'. As illustrated below, between September 1939 and March 1940, the Command sustained loss rates of 7.2 percent per sorties dispatched. This triggered a subsequent change in bombing policy in October 1939, with Bomber Command ordered to perform their missions chiefly at night.[15] The loss rates suffered by the Command during the first month of hostilities provided the first indication of the potency of the *Luftwaffe* IADS. Initial RAF efforts to comprehend the extent of the IADS were restricted to gathering intelligence on the IADS' electronic ORBAT particularly regarding radar. In October 1939 the Y-Service, the RAF's ELINT-gathering service commenced its hunt for *Luftwaffe* radar. The official record of RAF Signals during the Second World War noted that these efforts yielded little useful ELINT despite the fact that, at this stage in the war, the *Luftwaffe* had at least eight FuMG-80 *Freya* radars in service.[16] Each of these radars had a range of around 64.8nm (120km) for an air target flying at an altitude of 26,000 feet/ft (8,000 metres/m) on the east and north Frisian Islands in the North Sea off the northern coast of Germany guarding the sea approaches to the country's North Sea ports and the naval bases which the Command had been authorised to attack.[17]

Despite the limited knowledge of the IADS electronic ORBAT, the RAF received an unexpected advantage in early November 1939 in the form of the Oslo Report. This was drafted by an anonymous author revealed upon his death in 1989 to be the German mathematician and physicist Hans Ferdinand Mayer, and was posted to the British Embassy in Oslo, which despatched it to Military Intelligence Section-6 [MI6] for analysis. The report was duly examined by Dr. Reginald Jones, the assistant director of intelligence (science) at

[15] Overy, *The Bombing War,* p.246.
[16] AIR 41, *The Second World War 1939-1945, Royal Air Force Signals Volume VII, Radio Countermeasures* (London: Air Historical Branch, 1950), p.70.
[17] AIR 41/40, p.61

the Air Ministry. It provided an early treasure trove of information for Jones and his colleagues giving a useful situation report on the strength of the *Luftwaffe* IADS and its planned future development. The report provided details of the employment of the FuMG-80 radar during the first attack by the Command against naval targets at Wilhelmshaven on the night of 7/8 September 1939, describing how aircraft were detected by radar at a range of 64.8nm (120km) from the German coast. The report continued to provide a detailed technical description as to the workings of *Luftwaffe* ground-based air surveillance radar, which was not specifically referred to as the FuMG-80, alongside information regarding the planned proliferation of such radars across Germany by April 1940. Usefully, the report gave a description of the electronic countermeasure techniques which the British could employ to jam these radars, along with a discussion of the development of a second radar which would later be discovered to be the FuMG-62D FC/GCI radar.[18] While the Oslo Report was highly significant, in his memoirs, Jones explained that he experienced resistance regarding its veracity, with John Buckingham, the deputy director of research at the Admiralty, dismissing the report as a 'plant' by German intelligence. Jones continued that: 'the report was thereafter disregarded in the Ministries, which did not even keep their copies, and all I could do was to keep my own copy and use it as a basis for much of my thought'.[19] Thus, for the first seven months of the Second World War, from September 1939 to March 1940, Bomber Command effectively had no EW policy. As this discussion has illustrated, information regarding the IADS electronic ORBAT had been scant at best prior to the arrival of the Oslo Report. Even when this report was analysed by Jones, his confidence in its veracity was not shared by his colleagues, causing it to be officially ignored.

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[18] 'The Oslo Report' (Translated from German) @http://www.arcre.com/archive/wwii/oslo. (Accessed: 15 May 2017).

[19] R. Jones, *Most Secret War: British Scientific Intelligence 1939-1945* (London: Penguin, 2009 [1979], Kindle Edition), p.79.

Nevertheless, Jones' actions represented the emergence of a nascent Bomber Command SEAD posture. His retention of the report which would form the foundation for much of his thinking regarding the *Luftwaffe* IADS in the years ahead represented an example of Campaign level SEAD thinking. It will be recalled from the previous chapter that Baltrusaitis defined Campaign level SEAD as creating: 'increasingly favorable conditions for friendly operations by disabling enemy air defence systems, producing long term theater (sic) wide effects'.[20] The regard with which Jones held the report, and the important information that it contained, accorded with his aim of understanding the *Luftwaffe* IADs so that countermeasures could be devised to ease the Command's operations as it sought to pursue its strategic goals.

April - September 1940: The Expansion of the Strategic Air Campaign

On 9 April 1940, Germany commenced Operation *WESERÜBUNG*, the invasion of Denmark and Norway. Initial high losses suffered by Bomber Command from attacks by *Luftwaffe* fighters convinced its leadership, Everitt and Middlebrook argued that self-defending daylight formations of bombers were too vulnerable. The authors posited that 12 April: 'was undoubtedly the most important turning point in Bomber Command's war', as it marked the change of bombing policy to attacking targets under the cover of darkness, with only Bomber Command's Blenheim-BIs retained for daylight attacks as part of 2 Group. This marked the Command's first serious attempt to degrade the potency of the *Luftwaffe* IADS, by using the night to mask its aircraft from fighter visual detection. The second pivotal event for the

[20] Baltrusaitis, *Quest for The High Ground*, p.3.

Command during the spring of 1940 was the German invasion of France and the Low Countries, Operation *FALL GELB,* on 10 May. Everitt and Middlebrook stated that Germany's invasion of Western Europe: 'was another of the great turning points in Bomber Command's war', as the RAF: 'could finally start implementing their pre-war plans' regarding the attack of targets in Germany beyond naval targets.[21]

The Command's plans to this effect had been outlined in a directive issued to its AOC-in-C AM Charles Portal by the RAF's director of plans Air Commodore (Air Cdre.) John Slessor four days after Germany launched Operation *WESERÜBUNG*. The directive was drafted in the wake of the German invasion of Norway and proposed scenarios as to how the war might develop. One of Slessor's hypotheses was that Germany would invade either Belgium or the Netherlands, or both. The directive continued that: 'under this hypothesis, it is intended to initiate attacks on vital objectives in Germany', principally in the Ruhr Valley on that country's western border with the Netherlands with the intention of causing the 'maximum dislocation on the lines of communication of a German advance through the Low Countries'. The directive stipulated that the targets which should be attacked were troop concentrations, communications targets in the Ruhr such as rail marshalling yards and oil facilities in the same area.[22] Everitt and Middlebrook stated that Germany's invasion of France and the Low Countries presented an opportunity for the Command to finally start implementing its pre-war plans. These plans were exemplified by Western Air Plan-4 [WAP-4), one of several of the RAF's WAPs drafted before the outbreak of the war. The original WAP-4 was devised as an attack to delay the German invasion of Belgium, France and/or the Netherlands. Its prescribed

[21] C. Everitt, M. Middlebrook, *The Bomber Command War Diaries: An Operational Reference Book: 1939-1945* (Barnley: Pen and Sword, 2014 [1985], Kindle edition), p.24.
[22] '13 April 1940, Directive to Air Marshal Charles Portal, air officer commanding-in-chief from Air Commodore John Slessor, RAF director or plans', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* pp.109-111.

course of action was the attack of German military, rail and road communications.[23] Acknowledging the provenance of WAP-4, the new directive issued to the Command on 13 April was named WAP-4(C).

Initial attacks were performed to this end by Bomber Command on the night of 11/12 May with industrial and transportation targets in Mönchengladbach, close to the German-Dutch border, attacked. Overy argued that these efforts did not achieve much as Bomber Command's attacks were dispersed over several distinct objectives with 'little effect'.[24] Arthur Harris, who would be appointed AOC-in-C of Bomber Command in February 1942 argued in his memoirs that attacks against rail targets had little impact on disrupting German communications, as damage could be quickly repaired, or bypassed by re-routing traffic.[25] The bombing campaign was further widened on 15 May when the cabinet of Churchill's government of national unity, which had been formed following the resignation of his predecessor Neville Chamberlain in the wake of the capitulation of Norway, agreed to Bomber Command attacking targets in Germany where civilians may be of risk of harm, provided those targets were considered military objectives. This policy was enacted on the night of 15/16 May with attacks by 96 medium bombers on targets around the Ruhr Valley. Ostensibly, the motivation for the cabinet taking this decision was said in the official RAF narrative to have been the result of the *Luftwaffe* bombing the city of Rotterdam on 14 May which: 'held to release the Allies from any obligation to restrict their targets' to those where civilian loss of life was avoidable.[26] This is disputed by Overy who argued that the explanations for the RAF's commencement of attacks against German economic and military

[23] 'Appendix 6: Western Air Plans 1 September 1939', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* pp.99-100.
[24] R.J. Overy, *The Air War 1939-1945* (Washington DC: Potomac Books, 2005), pp.29-30.
[25] A. Harris, *Bomber Offensive* (Barnsley: Pen and Sword, 2005 [1947], Kindle edition), p.36.
[26] AIR 41/40, p.38, p.82.

targets: 'have assumed that it was a response to the German bombing of Rotterdam on 14 May, but the first raid on München Gladbach (sic), had already taken place three days before', continuing that no mention of the attack against Rotterdam was made in cabinet discussions *vis-à-vis* the new bombing policy. Instead, Overy claimed that the decision was taken because Churchill was more disposed towards air bombardment for strategic results than Chamberlain, and the crisis in the Battle of France which had seen the collapse of the French Ninth Army and its surrender, along with the serious attrition of the French Second Army, which had allowed the German Army to make major gains in northwest France, was the motivation. Ultimately, Overy argued that: 'a government headed by Churchill rather than Chamberlain was always more likely to endorse a bombing campaign'.[27]

Although Bomber Command had commenced attacks against German strategic targets following the invasion of France and the Low Countries, it could not restrict its attentions exclusively to such targets. The changing situation on the ground, notably with regard to the Battle of France, caused the Command to divide its focus between strategic targets, and those which would support France's continued resistance to the German invasion following Operation Dynamo; the evacuation of Allied soldiers from the Channel coast at Dunkirk in northwest France after their encirclement by the German Army. Thus, on 4 June AVM William Sholto-Douglas, deputy chief of the Air Staff sent a new directive to Portal. This specified that Bomber Command would continue to provide enhanced support to French forces, while attacking German oil targets. As the directive stated, the Command was to: 'complete the offensive against German oil resources … (while being prepared) at short notice to divert at least a high proportion of (its) effort to collaboration in the defensive battle

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[27] *Ibid.*, and Overy, *The Bombing War*, p.246.

on the ground'. In addition to the attacks on German oil targets, and support of ground operations, the directive stipulated that Bomber Command should attack the German aircraft industry as a second priority to the anti-oil efforts. Despite the Command now being authorised to hit targets in Germany which caused an inevitable rise in civilian casualties, the directive stressed that: 'In no circumstances should night bombing be allowed to degenerate into mere indiscriminate action, which is contrary to the policy of His Majesty's government.'[28]

The emphasis on the German aircraft industry would receive added impetus in a further directive issued to Bomber Command on 20 June; five days before the capitulation of France. This stated that: 'the primary objective of the Air Striking Force must be directed towards those objectives which will have the most immediate effect on reducing the scale of air attack on this country'. The directive also noted that canal and rail communications targets should continue to be attacked, while oil targets were relegated to third place. New targets were added to Bomber Command's responsibilities via this directive, not least being the destruction of crops in Germany from mid-July using new incendiary weapons. Finally, anticipating the future danger to the UK, with French Channel and Atlantic ports now firmly in German hands, the directive stressed that the Command should be prepared: 'at short notice to divert the bomber force, and particularly the medium bombers, to the attack of an enemy force at the ports of departure and subsequently at sea or at the points of landing in this country'.[29]

The RAF's emphasis on OCA, of which attacking the German aircraft industry was one part, continued into mid-July when a further directive sent from Sholto-Douglas to Portal stipulated

[28] '4 June 1940 Directive from Air Vice-Marshal WS Douglas to Air Marshal CFA Portal' in Frankland, Webster, *The Strategic Air Offensive Against Germany,* pp.111-115.
[29] *Ibid.*

that Bomber Command must direct its efforts towards targets in Germany that could reduce the threat of air attack against the UK. Simultaneously, this reduced the scale of effort that the Command was to direct against communications targets. Moreover this directive included the first indication that Bomber Command was to concentrate its attacks, observing that, as far as industrial targets were concerned: 'attacks have hitherto been too dispersed and that, in consequence, few objectives have sustained sufficient damage to put them out of action for any length of time'. The remedy, suggested by the directive, was for the Command to: 'direct a greater weight of attack on fewer targets with a view to complete destruction rather than harassing effect'.[30] Bomber Commands' priorities were changed once again at the end of July when the force was instructed to prioritise attacks against Germany's electricity generation capacity as the RAF felt: 'serious damage to any one power plant would cause a considerable reduction in industrial output'.[31] Overy observed that this constant change in targeting priorities experienced by the Command since April 1940 prevented it from focusing its efforts against any single target, and delivering a commensurate level of destruction.[32] Harris also argued that the strikes against German industry and communications at this point in the war were fruitless, yet he conceded that Bomber Command's early attacks against Germany did pay some important dividends. While the effort which the Command could exert against its allotted targets was arguably minimal, Harris believed that such attacks were useful: 'if only for the purpose of testing and probing the enemy's defence'. He continued by arguing that to have desisted from such attacks for the purpose of conserving the Command's aircrew and aircraft for a latter stage in the war would have left it with: 'no chance of keeping pace with the enemy's countermeasures'. The missions flown during the spring and summer of 1940

[30] '13 July 1940 Directive from Air Vice Marshal WS Douglas to Air Marshal Sir Charles Portal', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.119
[31] '30 July 1940 Directive from Air Commodore JS Slessor to Air Marshal Charles Portal', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.109-111, p.123.
[32] Overy, *The Bombing War*, p.255.

meant that the Command, according to Harris, was: ‘able to appreciate without any sudden and catastrophic rise in casualties, the effect of the enemy’s growing defences’. This resulted in Bomber Command taking measures to avoid the *Luftwaffe* IADS, if not to suppress it, by increasing the altitude at which missions were performed to position aircraft, as far as was possible, outside the range of *Luftwaffe* AAA.[33]

While Bomber Command was to garner an understanding of the sophistication of the *Luftwaffe* IADS as they increased the weight of their attacks on German targets in the spring and summer of 1940, the commencement of attacks against targets in the Ruhr Valley would have a discernable effect on the IADS. *Luftwaffe’s* reactions to the Command’s actions was to strengthen the IADS, a task given to *General der Flieger* Josef Kammhuber whom in July 1940 was placed in command of coordinating its ground-based air defence (AAA, searchlights and radar) elements. Kammhuber developed a sectorised IADS which became known as the ‘Kammhuber Line’. The Kammhuber Line, the workings of which are discussed in more detail below, consisted of invisible ‘boxes’ each of which was 247.1 square miles (640 square kilometres) in size and followed an approximate axis from the German North Sea coast south-westwards through the Low Countries and into France, following that country’s capitulation on 25 June.

Everitt and Middlebrook have argued that the *Luftwaffe* IADS lacked effectiveness at this point in the war. They stated that the force was unprepared for Bomber Command’s commencement of night missions and that *Luftwaffe* fighters were devoid of AI radar, and relied on either searchlight or moonlight illumination to find their targets. In addition,

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[33] Harris, *Bomber Offensive,* p.38.

Luftwaffe fighters had a significant risk of being shot down by their own side: 'The general story is of a very late and slow start by the German night fighter force.'[34] However, the loss rates experienced by the Command between April and August 1940 were significant: The missing and crashed average percentage per month for sorties despatched was 7.2 percent (see figure III). This fell between August and September 1940 to 3.3 percent. Yet the IADS' proliferation and sophistication could never have been expected to remain static as Bomber Command increased its tempo of attacks against German targets from April 1940, hence there was every chance that the IADS could inflict yet more damage in the future as the Command intensified its efforts.

Figure III – Bomber Command Losses for Sorties Despatched: April - September 1940

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Apr-40	Night	489	22	4.5%
	Day	167	15	6.0%
	Total	**656**	**37**	**5.6%**
May-40	Night	1617	24	1.5%
	Day	802	52	6.5%
	Total	**2419**	**76**	**3.1%**
Jun-40	Night	2484	33	1.3%
	Day	812	32	3.9%
	Total	**3296**	**65**	**2.0%**
Jul-40	Night	1722	43	2.5%
	Day	616	36	5.8%
	Total	**2338**	**79**	**3.4%**
Aug-40	Night	2188	63	2.9%
	Day	417	18	4.3%
	Total	**2605**	**81**	**3.1%**
Sep-40	Night	3141	86	2.7%
	Day	98	1	1.0%
	Total	**3239**	**87**	**2.7%**

[34] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.48.

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Much as he had in 1939 upon receiving the Oslo Report, Jones argued that the key to understanding the potency of the *Luftwaffe's* IADS was to gather as much intelligence as possible on the FuMG-80 radar concerning its appearance and performance, via the collection of imagery and ELINT on the FuMG-80s which had been moved by the *Luftwaffe* to the French coast opposite the UK.[35] Nevertheless, while Jones was alert to the importance of gathering intelligence on the electronic elements of the *Luftwaffe* IADS, it would still be some time until Bomber Command developed coherent EW policies and SEAD postures. The situation for Jones, and his colleagues tasked with understanding the *Luftwaffe* IADS, remained unchanged from the first six months of the war, namely the acquisition of intelligence pertaining to the IADS' electronic elements. Jones' actions continued to adhere to the Campaign level SEAD definition as he was collecting intelligence on *Luftwaffe* radar with a view to understanding its workings so as to ease the eventual development of ECMs. He was therefore, in his own right helping, albeit in a small fashion, to create increasingly favourable conditions for friendly operations.

September - December 1940: Towards Area Bombing

The *Luftwaffe* started bombing targets in the UK in the summer of 1940 with the commencement of Operations *Loge* and *Seeschlange* with attacks against London and other industrial cities around the country. As the *Luftwaffe* commenced its attacks, Bomber Command moved inextricably towards a bombing policy which would emphasise the attack of area targets in Germany. Writing in a memorandum Churchill stated that:

[35] Jones, *Most Secret War,* p.207

> (F)ighters are our salvation but the bombers alone provide the means of victory. We must therefore develop the power to carry an ever increasingly volume of explosives to Germany, so as to pulverise the entire industry and scientific structure on which the war effort and economic life of the enemy depends.[36]

As noted above, Overy argued that the commencement of attacks against German economic and industrial targets in mid-May 1940 occurred because Churchill was more disposed to air bombardment than his predecessor. Churchill's 3 September memorandum certainly illustrated a lack of political reticence towards widening the scope and weight of the RAF's bombing offensive. Yet while Churchill had underlined his support for such a course of action, in September 1940 the UK was facing the prospect of a German invasion, for which the launch of *Loge* and *Seeschlange* were the overture. The need to employ Bomber Command to reduce the risk of invasion was illustrated in the 21 September directive sent from Sholto-Douglas to Portal. The key priority of Bomber Command, this directive specified, was that: '(i)n the immediate future, while the imminent threat of invasion remains, the greater part of the bomber effort must continue to be employed against anti-invasion objectives'. The directive added that the selection of these targets therein would: 'depend on reconnaissance and other information' which was to be shared with the Command on a daily basis. Nonetheless, the directive did state that the primary aim of Bomber Command's anti-invasion efforts was to be directed against marine craft and merchant shipping which could assist the invasion. It added that the Command must also be ready to continue its attacks against targets in Germany either instead of, or concurrent with, these efforts. Meanwhile, the directive downgraded the importance of attacks against the German aircraft industry, while stating that attacks against *Kriegsmarine* submarine targets ashore were to continue in light of

[36] AIR 41/40, p.118.

German *Unterseeboot* [U-boat] submarine activity in the north-western sea approaches to the UK. Additionally, the Command's Blenheim-BI force was to attack German communications targets when weather permitted, while attacks were to continue against Germany's oil industry: 'from time to time in the light of information on the destruction caused and the success achieved by our attacks'. Finally, although it was the last priority in the directive, the document provided an important insight into Bomber Command's thinking regarding area attacks. In a section discussing attacks against Berlin, the document stated that the German capital possessed no objectives: 'of importance to our major plans'. This seemed a strange position given the concentration of German political and military power in the city, although it reflected the British preoccupation with prosecuting industrial targets in the west and southwest of Germany to degrade the country's war-making potential. However, the directive did state that when weather conditions permitted, attacks against Berlin should be performed: 'to cause the greatest possible disturbance and dislocation both to the industrial activities and to the civil population generally in the area'.[37] The Command had begun attacks against Berlin on 25 August as retaliation for the bombing of London on the night of 23/24 August.[38]

While Churchill's memorandum had underscored the Prime Minister's fervency for the employment of Bomber Command as a means of devastating German industrial and economic life, the appointment of Portal as chief of the air staff brought a RAF staff officer who was prepared to deliver Churchill's vision. Portal had served as the Command's AOC-in-C from April 1940 until 25 October 1940. He believed that targets in Germany should be selected in populous, industrial areas which should then be attacked with a heavy concentration of aircraft. The rationale was that such attacks would destroy the intended target while having an

[37] '21 September 1940 Directive from Air Vice-Marshal WS Douglas to Air Marshal Sir Charles Portal', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.124-127.
[38] AIR 41/40, p.119.

adverse destructive and psychological (dubbed ‘moral’) effect on the civilian population in the target’s vicinity. Ordnance dropping close to the target could have secondary effects such as the destruction of water mains. Such heavy attacks were recommended to be performed at night, and employ incendiary weapons with the intention of causing destruction and providing a visual marker for bombers following the lead aircraft during the attack.[39] Everitt and Middlebrook argued that the prosecution of such targets would also act as justifiable retaliation for the *Luftwaffe* taking the war to London and other cities around the UK.[40] Nevertheless, despite the promotion of Portal as an advocate of area bombing, and Churchill as a willing recipient of the former’s theories, the Command’s emphasis would not immediately be directed against such targets.

A directive sent from the Air Ministry to Bomber Command on 30 September reflected the changing strategic reality faced by the UK at this point in the conflict. Operation *Seelöwe* (Sea Lion), Germany’s planned invasion of the UK, had been postponed indefinitely on 17 September. While the directive conceded that, despite the cancellation of the invasion, ports in occupied Western Europe still contained concentrations of vessels which could be used to support the invasion, the late summer/early autumn weather had caused the threat to diminish. The directive continued that Bomber Command’s emphasis must now be on the objectives outlined in the 21 September directive, with the employment of heavy bombers to this end, and the provision that Bomber Command would be redirected to anti-invasion targets at short notice, should the strategic situation require this.[41]

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[39] *Ibid.* p.144
[40] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.73.
[41] ‘30 September 1940 Directive from The Air Ministry to Bomber Command’, in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.127.

The Command's priorities were to change once more in late October, with the issuing of a directive from Sholto-Douglas to AM Richard Peirse, whom had become AOC-in-C of Bomber Command upon Portal's promotion in late October. This new directive reflected the latter's position regarding the psychological and *materiel* effect he believed area bombing could have. With the threat of invasion receded, the directive stressed that bombing policy now needed to examine: 'the extent to which we can achieve a more decisive effect, both in the material and moral spheres by a greater concentration of our offensive air attacks'. The expected psychological effect of the new policy was intended to 'affect the morale of the German people when they can no longer expect an early victory and are faced with the near approach of winter and the certainty of a long war'. In terms of priority, the directive stressed the attack of oil targets during moonlit nights, and when weather conditions were favourable.[42] When the attack of oil targets was not possible, the directive stated that German aluminium plants must be struck, but crucially it also emphasised that:

> (A)s an alternative to the attacks designed for material destruction against our primary objectives, it is desired that regular concentrated attacks should be made on objectives in large towns and centres of industry, with the primary aim of causing very heavy material destruction, which will demonstrate to the enemy the power and severity of air bombardment and the hardship and dislocation which will result from it.[43]

Such attacks were to include the employment of both incendiary and high explosive bombs, plus delayed action bombs and mines, the intention being not only to cause destruction, but also to greatly hamper the ability of the emergency services to respond to the initial attack.[44] During the intervening period between attacks against towns and centres of industry Bomber Command was to continue to direct its effort against oil targets, marshalling yards; the

[42] '30 October 1940 Directive from Air Vice-Marshal WS Douglas (Deputy Chief of the Air Staff to Air Marshal Sir Richard Peirse', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.128.
[43] *Ibid.*, p.129.
[44] *Ibid.*

delivery of sea mines and attacks against ashore submarine facilities, invasion ports and *Luftwaffe* night bomber aerodromes so as to reduce the bombing threat against the UK.[45]

Nonetheless, during the summer of 1940, the *Luftwaffe* IADS had continued to develop while the intelligence picture of its sophistication available to the Air Ministry deepened. The first year of the war saw the Air Ministry's knowledge of the *Luftwaffe* IADS expand thanks to the interest taken therein by Jones. Although Bomber Command had not yet taken the step of drafting an EW policy and enacting a subsequent SEAD posture at this stage of the war, an understanding of the *modus operandi* of the *Luftwaffe* IADS, notably the Kammhuber Line, was developing. Jones observed that in October 1940, a British bomber had become the victim of the first successful interception which employed a combination of a *Luftwaffe* fighter and a FuMG-62D radar. The *Luftwaffe's* concept of operations in this regard employed two FuMG-62D radars; one to track the target and one to track the fighter. Using radio communications, the fighter was vectored by a ground controller towards its target.[46] Once again, Jones' knowledge of the *Luftwaffe* IADS was deepening thanks to the ELINT being gathered *vis-à-vis* the IADS. Yet the Command had still to develop an EW policy and SEAD posture which would not occur until March 1941 when it would make its first tentative forays into the application of ECMs against the IADS, and October 1942 when the Command would draft a coherent EW policy. Jones had been Campaign level SEAD minded in his gathering of ELINT pertaining to the IADS since the outbreak of the war and it would be several months until the Command's SEAD efforts would extend beyond the enhancement of its electronic ORBAT.

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[45] *Ibid.*, pp.190-131.
[46] Jones, *Most Secret War*, p.243.

December 1940 – December 1941: Mounting Losses

Everitt and Middlebrook argued that the first demonstration of Bomber Command's new emphasis *vis-à-vis* cities and towns with industrial targets that could be hit for destructive as well as psychological effect occurred on the night of 16/17 December 1940, with the Command's attack of Mannheim, southwest Germany using a force of 134 aircraft, with the centre of the city being the aim point and the bombers delivering incendiary weapons.[47] Yet characteristic of Bomber Command's changing priorities during 1940, the focus of its attacks were changed once again in a directive of 15 January 1941 back to oil targets. Whereas Bomber Command had been directed to attack oil targets amongst other targets in the 30 October 1940 directive, the 15 January directive stressed that: 'the sole primary aim of (the) bomber offensive, until further orders, should be the destruction of Germany's synthetic oil plants'. The reason for this being that available intelligence had revealed that Germany and her allies: 'will be passing through their most critical period as regards their oil resources during the next six months'. The only deviation from oil targets permitted by the directive were attacks against ports when invasion was deemed to be imminent, and attacks against naval targets when directed and when weather conditions allowed.[48] Overy argued that the directive's emphasis on oil targets was a failure. He stated that it had resulted in oil targets being struck on three nights during the entirety of January and February, with Bomber Command expending more effort against naval and port targets, which were easier to locate and attack. Overy continued that the War Cabinet had approved Bomber Command's policy on 7 January, but added the proviso that attacks against towns and cities, as had been authorised in the 30 October directive were to continue when weather conditions prohibited

[47] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.89.
[48] '15 January 1941 Directive from Air Chief Marshal Sir Wilfrid Freeman (Vice Chief of the Air Staff) to Air Marshal Sir Richard Peirse', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.132-132.

attacks against oil targets; the consequence was that such targets had been attacked twice as many times compared to oil targets in January and February as large urban targets were comparatively easier to hit in the reduced visibility caused by bad weather compared to comparatively smaller oil installation targets.[49]

Bomber Command finally abandoned its efforts to attack German oil facilities as per the 15 January directive in early March, when a new directive was issued to the Command to attack *Kriegsmarine* targets, principally U-boat facilities and Focke-Wulf FW-200 Condor maritime patrol aircraft which were attacking the maritime link for supplies of food and *materiel* between the United States and the UK. The directive added that some of Bomber Command's effort should be maintained against oil and other targets outlined in the 15 January directive, but that the chief effort was to be directed against submarine and FW-200 bases in Germany and occupied Europe. Tantalisingly the directive added that: 'Priority of (target) selection should be given to those in Germany which lie in congested areas where the greatest moral effect is likely to result.'[50] Furthermore, in a portent of the direction in which he was to take the Command in the near future Harris, as the deputy chief of the Air Staff since November 1940, sent a further directive to Pierse which added the city of Stuttgart in southwest Germany, and retained Mannheim, as part of the list of targets *vis-à-vis* the anti-submarine campaign; both being cities which manufactured diesel engines and electrical equipment used by U-boats. These cities, Harris stated, 'are suitable as area objectives and their attack should have a high morale value'.[51] Thus, while the 30 October directive, which first outlined area

[49] Overy, *The Bombing War*, p.264.
[50] '9 March 1941 Directive from Air Chief Marshal Sir Wilfrid Freeman (Vice Chief of the Air Staff) to Air Marshal Sir Richard Peirse', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.133.
[51] '18 March 1941 Directive from Air Vice Marshal AT Harris (Deputy Chief of the Air Staff) to Air Marshal Sir Richard Peirse', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.135.

bombing, may have been subsumed by the subsequent directives of 15 January and 9 March, the RAF had still not altogether abandoned its commitment to area bombing.

Away from the attack of oil facilities, urban centres and naval targets during the first two years of the war, Bomber Command did commence kinetic OCA efforts in January 1941 following the commencement of Circus operations. The concept of operations for Circus was to have a small force of Blenheim-BIs escorted by a large number of RAF Fighter Command aircraft. The Blenheim-BI force would attack a target of relatively little importance in occupied Europe, notably around the Pas de Calais in northwest France, or some parts of Belgium due to aircraft range limitations, with the aim of causing a corresponding scramble of *Luftwaffe* fighters. These fighters would then be attacked by Fighter Command aircraft with the intention of waging a war of attrition against *Luftwaffe* fighter strength.[52] While the RAF commenced the Circus initiative, its EW operations were yet to be activated, and the emphasis of Jones remained the collection of ELINT pertaining to the *Luftwaffe* IADS, with further evidence of the existence of the FuMG-80 radar coming to light for Jones and his colleagues via RAF photographic reconnaissance focused on the coastal town of Auderville in northwest France. The discover of the FuMG-80 was important as Jones was finally able to match the physical appearance of the radar with its RF, hence being able to match similar transmissions with other similar objects photographed across the coast of Western Europe. The discovery of the FuMG-80's physical and electronic characteristics enabled Jones to further deepen his knowledge of the IADS electronic ORBAT. At the same time he was also amassing ELINT regarding the existence of the FuMG-62D radar and in particular its importance in *Luftwaffe* fighter tactics. Based on the contents of the Oslo Report, Jones had worked to gather ELINT

[52] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.73.

by detecting transmissions between 560 megahertz [MHz] and 600MHz, detecting such RF signals being transmitted from the French Channel coast.[53] Jones' emphasis on the FuMG-62D coincided with the increased deployment of this radar throughout the Kammhuber Line as the *Luftwaffe* continued to enhance its defences.

Figure IV – Bomber Command Losses for Sorties Despatched: October 1940 - March 1941

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Oct-40	Night	2242	59	2.6%
	Day	172	1	0.6%
	Total	**2414**	**60**	**2.5%**
Nov-40	Night	1894	84	4.4%
	Day	113	2	1.8%
	Total	**2007**	**86**	**4.3%**
Dec-40	Night	1385	60	4.3%
	Day	56	2	3.6%
	Total	**1441**	**62**	**4.3%**
Jan-41	Night	1030	24	2.3%
	Day	96	4	4.1%
	Total	**1126**	**28**	**2.5%**
Feb-41	Night	1617	48	3.0%
	Day	124	4	3.2%
	Total	**1741**	**52**	**3.0%**
Mar-41	Night	1728	71	4.1%
	Day	162	4	2.5%
	Total	**1890**	**75**	**4.0%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Figure IV demonstrates that average losses for Bomber Command per sortie despatched between October 1940 and March 1941 only increased slightly to 3.4 percent, from the 3.3 percent experienced between April and September 1940. However, the damage that the

[53] Jones, *Most Secret War*, p.213, p.310.

Luftwaffe IADS was able to inflict on Bomber Command was sufficient for its aircrews to employ their own crude ECMs in the hope of reducing the chance of a successful interception of their aircraft. As Bomber Command intensified its attacks over Germany and occupied Europe a theory developed amongst aircrews that switching on and off their aircraft's IFF Mk.I Identification Friend or Foe [IFF] radio transponders which were designed to transmit an RF signal to ensure that the aircraft was depicted as friendly to RAF ground-based air surveillance radars, would dowse *Luftwaffe* searchlights. Bomber Command then recommended in March 1941 that crews should switch the IFF sets on and off again every five seconds. However Bomber Command was never able to amass evidence that this practice was sufficient in dowsing *Luftwaffe* searchlights, and Jones even argued that the practice of activating the IFF at any point when over hostile territory could provide a means for the *Luftwaffe* to detect Bomber Command aircraft via these RF transmissions.[54] The use of the IFF to this end may have been little more than a self-devised palliative by which the crews would believe that they were protected from *Luftwaffe* searchlights while actual evidence to this end was all but non-existent. Although Jones' efforts to enhance the electronic ORBAT of the *Luftwaffe* IADS at this stage in the war were representative of a Campaign level approach to SEAD, the adoption of the IFF technique was an example of SEAD being applied at the Localised level. As Baltrusaitis stated, Localised SEAD is intended to disrupt, degrade and destroy elements of an IADS at a defined point over a defined timeframe:[55] That aircrews were performing such actions when they were in the proximity of searchlights accorded closely to the Localised SEAD level definition. Moreover, Bomber Command's acceptance of the practice was indicative of a reactive EW policy as the application of the IFF technique was a consequence of the threat posed by *Luftwaffe* searchlights, although the practice was

[54] AIR 41, p.77.
[55] Baltrusaitis, *Quest for The High Ground*, p.3.

performed by aircrew out of desperation to protect their aircraft, rather than on the basis of evidence that this practice was effective.

Meanwhile, as Jones and his colleagues were deepening their knowledge regarding the FuMG-80 and FuMG-62D radars, evidence was coming to light that *Luftwaffe* fighters were being outfitted with AI radar, with a *Luftwaffe* prisoner of war providing evidence of the existence of the FuG-202 *Lichtenstein* AI radar.[56] By May 1941, the Air Ministry had amassed enough intelligence to gain a thorough understanding of the *Luftwaffe* IADS as it then was. The FuMG-80 radar chain was thought to stretch from the West Frisian Islands to the French port of Brest close to the most westerly point of the French Atlantic coast, with the possibility that this chain stretched from Denmark along the coast of Western Europe to the Franco-Spanish border. The existence of FuMG-62D radars both along the coast and inland was also determined, together with the RF transmission properties of these respective radars.[57]

This growing comprehension of the *Luftwaffe* IADS strength occurred in tandem with the issuing of a new directive on 9 July which renewed Bomber Command's offensive against German 'morale' while directing the Command to attack German communications. The change of policy, the directive specified, was as the result of a: 'comprehensive review of the enemy's present political, economic and military situation (which disclosed) that the weakest points in his armour lie in the morale of the civil population and in his inland transportation system'. The reasoning for this conclusion was renewed German military activity with the commencement of Operation BARBAROSSA, the invasion of the Soviet Union, on 22 June and a belief that the Command's attacks on industrial targets were affecting the psychological

[56] Jones, *Most Secret War*, p.316.
[57] AIR 41, pp.70-71.

health of the German civilian population.[58] The directive was unambiguous in its wording that Bomber Command:

> (d)irect the main effort of the bomber force, until further instructions, towards dislocating the German transportation system and to destroying the morale of the civil population as a whole and of industrial workers in particular.[59]

The target list in the directive placed a heavy emphasis on cities in Germany's Ruhr Valley, Rhineland industrial heartland in the west and southwest of the country. The emphasis of the attack of communications targets, notably railways, was intended to isolate these areas from the rest of the country, from occupied Europe and from the war with the Soviet Union now developing in the east. Other targets detailed in the directive included inland waterways and rubber factories with a view to causing serious disruption to German tire production, and hence road transportation, in addition to naval targets, the latter of which would serve a diversionary function.[60] Although it has been argued that both Churchill and Portal were convinced that area bombing attacks would have a profound psychological effect on the German population, Overy argued that the decision to pursue such a bombing policy was also the result of the Command lacking the necessary technology to perform anything more precise than indiscriminate attacks against urban and communications targets.[61]

The relative ineffectiveness of Bomber Command to date against its targets was demonstrated in the so-called Butt Report which was drafted by David Bensusan-Butt, the private secretary of Professor Frederick Lindemann, the government's chief scientific officer, and published on

[58] '9 July 1941, Air Vice-Marshal NH Bottomley (Deputy Chief of the Air Staff) to Air Marshal Sir Richard Peirse', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.135-136.
[59] *Ibid.*
[60] *Ibid.*
[61] Overy, *The Air War*, pp.38-39.

18 August 1941. Bensusan-Butt's work examined the effectiveness of Bomber Command aircraft in successfully striking their targets via the examination of photoreconnaissance performed after Bomber Command attacks and by the statistical analysis of each operation.[62] The report's findings highlighted the acute problem of accuracy in Bomber Command. Bensusan-Butt noted that of those aircraft which reported having hit a target, only one in three scored hits within five miles of the target. When Bomber Command was attacking targets in Germany writ large, this number decreased to one in four, and then to one in ten when aircraft were attacking targets in the Ruhr Valley. The report also noted the impact that the *Luftwaffe* IADS was having on Bomber Command's accuracy, in particular AAA which: 'reduced the number of aircraft getting within 5 miles of their target in the ratio three to two'.[63]

The Butt Report was published against a backdrop of increasing Bomber Command casualties. For example, during the spring it introduced a new variant of the FuMG-62D known as the Telefunken FuMG-65 *Würzburg Riese* (Wurzburg Giant); an FC/GCI radar with a longer range of around 32.4nm (60km) as opposed to the approximately 21.6nm (40km) of the FuMG-62D.[64] As figure V states, Bomber Command casualties increased during the second part of the year, in comparison to the loss rates of 3.3 percent per sorties despatched between October 1940 and March 1941. Bomber Command losses per sortie dispatched increased to an average of 4.2 percent for the final nine months of 1941, compared to average loss rates of 3.4 percent for the period October 1940 to March 1941. In particular, loss rates began to increase appreciably from July 1941 reaching 4.9 percent, and would not diminish until December.

[62] R.J. Overy, *Why The Allies Won* (Vintage Digital, 2012, Kindle edition), p.220.
[63] 'The Butt Report' @https://etherwave.files.wordpress.com/2014/01/butt-report-tna-pro-air-14-12181.pdf
[64] Price, *Instruments of Darkness*, p.58.

Figure V – Bomber Command Losses for Sorties Despatched: April to December 1941

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Apr-41	Night	2249	68	3.0%
	Day	676	30	4.4%
	Total	**2925**	**98**	**3.4%**
May-41	Night	2416	53	2.2%
	Day	273	23	8.4%
	Total	**2689**	**76**	**2.8%**
Jun-41	Night	3228	91	2.8%
	Day	531	25	4.7%
	Total	**3759**	**116**	**3.1%**
Jul-41	Night	3243	119	3.7%
	Day	582	69	11.9%
	Total	**3825**	**188**	**4.9%**
Aug-41	Night	3344	166	5.0%
	Day	468	40	8.5%
	Total	**3812**	**206**	**5.4%**
Sep-41	Night	2621	138	5.3%
	Day	263	15	5.7%
	Total	**2884**	**153**	**5.3%**
Oct-41	Night	2501	108	4.3%
	Day	138	18	13.0%
	Total	**2639**	**126**	**4.8%**
Nov-41	Night	1713	104	6.1%
	Day	43	0	0.0%
	Total	**1756**	**104**	**5.9%**
Dec-41	Night	1411	44	3.1%
	Day	151	7	4.6%
	Total	**1562**	**51**	**3.3%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

These increasing loss rates coincided with the RAF's first realistic foray into the application of ECMs. In July 1941, a Blenheim-BI performing radar calibration flights over the North Sea had triggered a major scramble of *Luftwaffe* fighters in the Lille/Courtrai areas of north-western France and south-western Belgium. For the process of calibrating RAF ground-based air surveillance radars, the Blenheim-BI was carrying modified IFF equipment designed to receive a radar transmission and then retransmit an identical transmission back to the radar station at a greatly amplified power level.[65] This concept became the basis of the RAF's Moonshine ECM by which an aircraft equipped with this countermeasure would receive an RF transmission from an FuMG-80 radar and then retransmit the original transmission at greatly increased amplification, which would exceed the level of amplification normally returned by an aircraft which had been detected thus giving the impression to the radar's operator that they had detected a large formation.[66] The Moonshine ECM will be discussed in more detail in the following chapter.

Concurrent with the development of the Moonshine ECM, the RAF was at last beginning to formulate an EW policy writ large. One of the earliest manifestations of this policy occurred during a meeting of the Radio Direction Finding [RDF, the early name for radar] Policy Subcommittee which was chaired by the RAF, although its meetings were also attended by representatives from the Royal Navy and British Army, when it was realised that the three services would need to coordinate their ECM and jamming efforts. The RDF Policy Subcommittee was chaired by Sir Henry Tizard, one of the British government's key scientific experts. Tizard had expressed misgivings about Bomber Command adopting ECMs to jam *Luftwaffe* radar and also believed that the level of technological sophistication of the electronic elements of the *Luftwaffe* IADS was lagging behind that of the RAF. Tizard's main concern was that the adoption of ECMs and jamming risked presenting the *Luftwaffe* with electronic techniques that it had perhaps not yet mastered and which could then be turned against the RAF, thus neutralising the initial advantage; the position of Tizard and some of his colleagues, while representing valid concerns, helps to explain why the Command waited for

[65] AIR 41, p.79.
[66] Streetly, *Confound and Destroy*, p.160.

a comparatively long time before adopting ECMs.[67] This is in contrast to the argument posited by Streetly whom stated that the Command did not employ ECMs at this stage of the war as it was required to maintain radio silence whilst over enemy territory. However, the official records of the Command's EW policy at the time stated that the reticence to employ ECMs was focused on these jamming war concerns. Despite Tizard's scepticism the Committee did consent to Bomber Command commencing small scale jamming under close observation by the Air Ministry.[68] This decision reflected a Campaign level approach to SEAD. The concerns of the Committee, Bomber Command and the Air Ministry was to reduce the Command's overall losses, not just during specific missions, as this reduction in losses was imperative to the overall success of the Command's efforts.

Concurrent with the Committee lifting the ban on Bomber Command's use of ECMs, the RAF began to enhance its knowledge of *Luftwaffe* fighter control tactics. From 1940, the Y-Service amassed ELINT regarding RF transmissions in the 3MHz to 6MHz waveband. By September 1941, it had discerned the operation of the *Luftwaffe* IADS fighter control system by which a fighter patrolled its own segment of airspace and was directed to its target illuminated by searchlights, by ground controllers using radio communications.[69] The efforts of Jones and his colleagues resulted in Bomber Command developing reasonable assumptions regarding the performance of the disparate radar systems comprising the *Luftwaffe* IADS. To this end, a memorandum from Bomber Command's Operational Research Service [ORS] stated an assumption that the range of the FuMG-80 radars which provided early warning to the IADS was 86.8nm (160.9km) with track information regarding ingressing aircraft transmitted directly to *Luftwaffe* fighters using encrypted Morse code Wireless Telephony

[67] AIR 41, p.73, p.76.
[68] Streetly, *Confound and Destroy*, p.15.
[69] AIR 41, p.71.

[W/T]. The memorandum articulated the ORS' belief that the FuMG-80 radar chain was used solely for the tracking of Command aircraft, and not for AAA or searchlight control. Nonetheless, the ORS was at the same time deepening its knowledge of the FuMG-62D radar following airborne ELINT collection which had been performed from St. Nazaire on the French Atlantic coast to Borkum in northwest Germany, and in the vicinity of Amsterdam, Paris and Utrecht. Although the memorandum conceded that comparatively little was known about the performance and role of the FuMG-62D, the ORS surmised that such radars were used for AAA fire control, searchlight control and inland tracking of aircraft once they had crossed the coastal FuMG-80 chain. While the Command was establishing a comprehensive assessment of the IADS, particularly with regards to its electronic ORBAT pertaining to the FuMG-80 and FuMG-62D radar families, and radio communications, the ORS noted that it had not gathered further evidence beyond what was already known concerning the *Luftwaffe's* use of AI radar.[70]

However, as Bomber Command's ORS deepened its understanding of the *Luftwaffe* IADS and broadened its electronic ORBAT, the Command's strategic air campaign was suspended. Bomber Command losses per sortie dispatched had reached 5.9 percent in November 1941. This was the highest rate sustained since May 1941, and reflected a general increase in Command losses for the final seven months of the year. The culmination of this upward trajectory was the suspension of most of Bomber Command's operations from 13 November while the War Cabinet debated the future of the bomber offensive and the Command in general. Everitt and Middlebrook argued that at this point in the war the Command's very existence was under threat not only in light of the losses it was sustaining, but from the

[70] Memo from the Bomber Command Operational Research Section, 14 October 1941. AIR 2/7609 Radar and Radio Countermeasures (Code B.61): RCM 'Moonshine' and 'Mandrel', 1941-1943.

political will to continue employing Bomber Command in night attacks against targets in Germany.[71]

Concerning the limited operations which the Command was allowed to continue, its light bomber force in the form of 2 Group was, from 8 November, to be tasked with attacking several targets including low-altitude strikes against precision targets and, as a secondary role, attacks against enemy airfields: 'to promote disorganisation and lessen the danger to the heavy and medium bombers of interception and destruction by German night fighters'.[72] Thus, while the Command had only taken baby steps so far regarding the commencement of electronic warfare against the *Luftwaffe* IADS, it was prepared to perform kinetic SEAD attacks against such targets. Bomber Command had, up until this point in the war, exhibited a fear of commencing a jamming war against the *Luftwaffe* IADS. Even if the Command had the desire to embark upon this course of action, it was not at this point in the conflict in possession of the required ECM technology. While the first two years of the conflict saw the Air Ministry and Jones in particular, concerning their efforts with drafting an increasingly detailed overview of the electronic capabilities of the IADS, such a course of action was both logical and prudent despite the cost in blood and aircraft that the IADS had shown itself to be increasingly able to inflict as 1941 unfolded. Put simply, Bomber Command needed to know what to jam before it could start to jam and the ELINT collection effort witnessed throughout the first two years of the war would pay dividends later on. As this thesis confines itself to examining the Command's EW policy and resulting SEAD posture, the role of the kinetic efforts of 2 Group, and other components of Bomber Command and RAF in general in performing kinetic SEAD against the IADS will receive no further examination. Nevertheless,

[71] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.186.
[72] AIR 41, p.282.

such a subject is worth further study given the paucity of discussion of the RAF's kinetic SEAD efforts during the conflict in the canon of literature.

Conclusions

The established canon of literature largely ignores Bomber Command's EW efforts between September 1939 and January 1941. This is not surprising, as Bomber Command did not commence its deployment of ECMs until October 1942, with the adaptation of its IFF Mk.1 equipment. Moreover, with the exception of Jones' work, the canon also largely ignores the emergence of a nascent Bomber Command EW policy in the form of the intentional gathering of ELINT relevant to the *Luftwaffe* IADS as a result of Jones' research.

The Command commenced the war devoid of either an EW policy or SEAD posture. The arrival of the Oslo Report in November 1939, while presenting an overview of the electronic elements of the *Luftwaffe* IADS, and future plans for its development, was officially ignored. Nonetheless Jones realised the value of the report to help to reduce the Command's losses. In this regard he exhibited Campaign level SEAD thinking, as he was already planning how *Luftwaffe* radar could be exploited to create increasingly favourable conditions for Bomber Command's operations. Given that EW was largely ignored by the Command during the two years of the war, its prevailing policy was one of avoiding, as far as was possible, the threat posed by the *Luftwaffe* IADS by flying at high altitudes to avoid AAA, rather than performing suppression. Nonetheless the intensification of attacks on German strategic targets by the Command triggered a corresponding intensification of the *Luftwaffe* IADS via the development of the Kammhuber Line, but this did not bring an immediate drafting of an EW policy, nor the evolution of a SEAD posture. Throughout the summer of 1940, Jones would remain Campaign SEAD minded, gathering information pertaining to the *Luftwaffe* IADS while the Command continued to refrain from suppressing the *Luftwaffe* IADS by electronic means.

This situation continued into the spring of 1941 with the notable exception that the RAF did embark upon OCA via the CIRCUS operation. Although this was an overwhelmingly kinetic effort that will receive no further examination, it did illustrate that the Command had finally decided to suppress the *Luftwaffe* IADS to reduce its losses. By March 1941, the Command's crews were using their IFF Mk.1 sets in a misguided attempt to extinguish *Luftwaffe* searchlights. This was an early example of a reactive EW policy manifesting itself at the Localised level. Moreover, in the face of mounting aircraft losses during the latter half of 1941 the decision was taken to allow Bomber Command to employ ECMs in support of its operations. While this was a clear example of a Campaign level approach to SEAD the decision represented a false dawn for the adoption of ECMs beyond the early employment of the IFF Mk.1 set given that Bomber Command operations were largely suspended from late 1941. Thus, during the first two years of the war, the Command had practiced a Campaign level approach to SEAD by deepening its knowledge of the electronic elements of the IADs. This was an example of reactive EW thinking, in the case of Jones' efforts and policy, as exemplified by the October 1941 ECM deployment decision, as both were pursued as a response to the threat that radar posed to the Command's aircraft. Secondly, the decision taken in late 1941 to allow the Command to commence the employment of ECMs was another example of a Campaign level SEAD approach, given that this was done to reduce overall Command losses. Yet the only ECM employed by the Command during this period was the IFF Mk.I set as a questionable countermeasure against *Luftwaffe* searchlights; an ECM which was very much an example of a Localised level approach to SEAD. It would not be until October 1942, as Bomber Command intensified its strategic air campaign and losses mounted therein, that the Command would finally embrace the potential of ECMs, and evolve coherent EW policies and SEAD postures; factors which will be examined in the following chapter.

CHAPTER THREE

BOMBER COMMAND ELECTRONIC WARFARE POLICY AND SUBSEQUENT SUPPRESSION OF ENEMY AIR DEFENCE POSTURE: JANUARY 1942 TO JULY 1943

Introduction

While Chapter Two examined the EW policy and SEAD posture of Bomber Command from the commencement of the Second World War until the suspension of Command operations in December 1941, this chapter will analyse the Command's EW policy and SEAD posture from its resumption of operations in early 1942 until July 1943, when the Command decided to raise a specific Group tasked with applying EW against the *Luftwaffe's* IADS. The chapter will initially discuss the decisions behind the resumption of the Command's strategic air campaign in February 1942, and the shift towards area attacks against German targets. It will then examine the importance of the appointment of AM Arthur Harris as the AOC-in-C of Bomber Command, and his influence regarding the need to reduce aircraft losses through the adoption of ECMs in light of the continuing proliferation of the IADS and the losses on the Command it was exacting. The chapter will continue by examining the debates surrounding the introduction of ECMs into Command service. Finally, it will analyse the Command's targeting priorities from early 1943 *vis-à-vis* the future allied invasion of Europe, and the need to establish air superiority over the *Luftwaffe*.

January-September 1942: Necessity Breeds Invention

Bomber Command's operations were suspended in late 1941 amid mounting losses. Its future and that of the strategic air campaign in general, was then debated by the War Cabinet. The Command survived this process and its continued employment against German targets was influenced by two events; the first being the Washington/ARCADIA Conference held in Washington DC between 22 December 1941 and 14 January 1942. Comprising the military and political leadership of the United Kingdom and the United States the conference was held to shape the Western Allies' future strategy. It yielded an agreement that an increasing level of bombardment would be directed against Germany. This was deemed as the essential prelude to any Allied invasion of continental Europe, while being the only immediate means through which the Allies could support the Russian offensive against Germany, by forcing a growing proportion of the German male population to man the country's air defences, thus depriving the German Army of personnel on the Eastern Front.[1]

The second event was the appointment of Harris as the Command's AOC-in-C in February 1942. Harris had previously served as Deputy Chief of the Air Staff [DCAS] from November 1940 and had argued that the bomber offensive thus far had been ineffective. He was acutely aware of the losses the Command had suffered and the impact this could have on its ability to continue attacking targets in Germany. He argued that the loss rates sustained during the final months of 1941 forced the Command to alter its defensive tactics.[2] Fundamental to Harris' thinking was the need to concentrate bombers into a 'stream' during the attack of a specific target so as to improve each aircraft's chance of survival through overlapping defensive

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[1] AIR 41, p.114, p.119.
[2] J. Grehan, M. Mace, *Bomber Harris: Sir Arthur Harris' Despatch on War Operations 1942-1945* (Barnsley: Pen and Sword, 2014, Kindle edition), p.43.

coverage, to enable more bombs to be delivered against the target and to overwhelm the IADS at particular points in the Kammhuber Line by providing too many targets for individual fighters to intercept.[3] The principle of concentration was further aided by the introduction of the Avro Lancaster-BI heavy bomber into service in February 1942. As Overy argued, this aircraft could carry a considerably larger bomb load of 14,000 pounds/lb (6,350 kilograms/kg) compared to the Command's existing main heavy bomber, the Armstrong Whitworth Whitley-BV which had a 7,000lb (3,175kg) bomb load. Thus a proportionally heavier weight of ordnance could be delivered against a specific area causing a higher level of focused destruction than the Command had delivered before.[4] The need for concentration would increase given that the IADS was far from static. Despite the Command's ORS building a detailed picture of the IADS' electronic ORBAT, as illustrated by the October 1941 memorandum discussed in the previous chapter, the IADS was subjected to frequent enhancements as the *Luftwaffe* sought to deepen its potency against an increasing number of Command sorties. For example, in the spring of 1942 the Command discovered that the FuMG-80 had been augmented by the Telefunken FuMo-51 *Mammut* ground-based air surveillance radar. This radar had a detection range of 160.6nm (297.6km) which would translate into additional early warning time, compared to the FuMG-80 radar which had a typical range 64.8nm (120km) for a target flying at 26,000ft (8,000m).[5] Moreover, while the discovery of the FuMo-51 radar was indicative of the *Luftwaffe's* willingness to meet the threat posed by the Command's aircraft, so was the realisation in February 1942 that the force possessed aircraft equipped with AI radar operating in the UHF bandwidth of 490MHz with a

[3] Jones, *Most Secret War*, p.304.
[4] R.J. Overy, *Why The Allies Won* (Vintage Digital, 2012, Kindle edition), p.103.
[5] Jones, *Most Secret War*, p.249 and A. Price, *Instruments of Darkness: The History of Electronic Warfare 1939-1945* (London: Greenhill Books, 2005 [1967], Kindle Edition), p.148.

range of 1.7nm (3.2km).[6] Meanwhile, German ENIGMA radio traffic intercepted by the RAF's Y-Service revealed the existence of fighter control stations using voice Radio Telephony [R/T] and Morse code W/T to vector these fighters towards Bomber Command aircraft.[7]

Harris' appointment was shortly preceded by Bomber Command's adoption of the GEE radio navigation system which provided bombers with a position accuracy of a few hundred metres at ranges of up to 300nm (556km). While space is insufficient to detailed the workings of the GEE system, it was intended to provide a relatively accurate fix over the Command's target to enable accurate bombing at night, in adverse weather or when a target was obscured. In a 14 February directive sent from AVM Norman Bottomley, DCAS, to AM John Baldwin, the acting AOC-in-C of Bomber Command, the latter was directed to employ the Command without restriction in favourable weather and avoiding extreme hazards. The directive observed that the introduction of GEE would compliment the principle of concentration as it would: 'confer upon (Bomber Command's) forces the ability to concentrate (its) efforts to an extent which had not hitherto been possible under the operational conditions with which you are faced'. The directive added that this effort was to be directed against: 'the morale of the civilian population and in particular of the industrial workers', while encouraging that, 'the scale of effort and tactics employed should be designed to incur the minimum casualties', with a recommendation that operations be performed at a high altitude with a reduced bomb load if necessary. The directive continued that the primary target selected for GEE should be

[6] Price, *Instruments of Darkness,* p.59.
[7] Jones, *Most Secret War*, p.316.

the city of Essen with Duisburg, Düsseldorf and Cologne (all in Western Germany), also being attacked.[8]

Harris would assume command on 22 February and the 14 February directive accorded with his views on strategic bombing. Davis-Biddle argued that Harris believed it was necessary to inflict as much material and psychological damage on Germany as possible. At the same time, the author posited that Harris dismissed attacks against specific targets such as Germany's oil and ball bearing industries as the work of so-called 'panacea mongers' who believed the Third Reich could be defeated by hitting specific targets that would stop its ability to continue the war.[9] Harris argued that the bomber offensive was the sole mechanism by which Germany would be forced to retain personnel in a defensive role to protect the country by manning the IADS and the country's emergency services, thus depriving Germany of frontline troops.[10] Davis-Biddle continued that the priority for Harris was the attack of German cities which were: 'the edifices sustaining and supporting modern life', that such targets 'concentrated everything important to a modern state', and that destroying large tracts of German cities would destroy the country's war-making potential.[11]

Furthermore, Harris realised the destructive potential of blending explosive and incendiary ordnance, Everitt and Middlebrook argued. The Main Force would initially drop explosive ordnance to block roads with masonry and debris from destroyed and damaged buildings to

[8] '14 February 1942 directive from Air Vice-Marshal NH Bottomley (Deputy Chief of the Air Staff) to Air Marshal JEA Baldwin (Acting Air Officer Commanding-in-Chief, Bomber Command)', in N. Frankland, C. Webster, *The Strategic Air Offensive Against Germany*, p.143.
[9] Davis-Biddle, *Rhetoric and Reality in Air Warfare*, p.201.
[10] Harris, *Bomber Offensive*, p.59.
[11] Davis-Biddle, *Rhetoric and Reality in Air Warfare,* p.201.

hinder the movement of the emergency services, notably the fire brigade.[12] This initial attack would be followed up by the use of incendiary and explosive ordnance, with the explosives creating entry points into buildings for the incendiaries to start fires.[13] Being able to concentrate the Main Force, Devereux argued, was also the result of the introduction of GEE.[14]

During early 1942, the Command was moving towards the adoption of ECMs and the realisation of a formal EW policy resulting from three distinct, yet interrelated, factors; the decision of the Washington/ARCADIA conference regarding the strategic air campaign, Harris' belief in concentration and the realisation that the radar and radio communications/navigation systems of the *Luftwaffe's* IADS were being continually enhanced. The move towards coherent Bomber Command EW policies was also achieved via the activation of the RCM Board. Its formation was agreed by the Chiefs of Staff Committee on 30 January 1942 and the Board's terms of reference included monitoring the use of ECMs, and any modifications necessary to ensure the efficacy of those ECMs. On behalf of all three services, it was to devise rules governing the use of ECMs; review proposals for new ECMs and advise on their use; monitor research and development work pertaining to ECMs and estimate future ECM requirements. The Board was to be chaired by the Air Ministry's Director of Signals given that the RAF was the largest user of ECMs at that point in the war, following the activation of the RAF's 80 Wing which was tasked with jamming the *Luftwaffe's Knickebein* radio navigation system.[15] Beyond the Command's initial forays into ECMs via the use of the IFF Mk.1 identification friend or foe transponder set, it was Fighter

[12] *Ibid.,* p.105.
[13] Everitt, Middlebrook, *The Bomber Command War Diaries*, p.202.
[14] Devereux, *Messenger Gods of Battle*, p.153.
[15] 'Terms of Reference and Composition of the RCM Board, 12 March 1942', AIR 20/8213, Radar and Radio Countermeasures (Code 61): RCM Board: minutes, reports and terms of reference, 1942-1945.

Command which undertook the majority of the RAF's ECM efforts particularly given concerns highlighted in the previous chapter regarding the commencement of a 'jamming war' should the Command adopt a similar approach. Hence Bomber Command was still bereft of an EW Policy until it took the decision to perform the wholesale jamming of the IADS in October of 1942.

The Command's area bombing offensive commenced on the night of 8/9 March when the city of Essen was attacked using the GEE system, with operations against the city concluding in June. The commencement of the area bombing offensive caused a corresponding increase in the Command's losses, as can be seen in figure VI. These increased from about four percent for the total number of sorties despatched in January to almost five percent by September. The dominant factor causing these increases, Bomber Command's official history argued, was the growing proliferation of the IADS' fighter force.[16]

Figure VI – Bomber Command Losses for Sorties Despatched: January - September 1942

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total Losses as a Percentage of Sorties Despatched
Jan-42	Night	2216	86	3.9%
	Day	24	0	0.0%
	Total	**2240**	**86**	**3.8%**
Feb-42	Night	1162	18	1.5%
	Day	252	15	6.0%
	Total	**1414**	**33**	**2.3%**
Mar-42	Night	2224	78	3.5%
	Day	131	2	1.5%
	Total	**2355**	**80**	**3.4%**
Apr-42	Night	3752	130	3.5%
	Day	246	16	6.5%

[16] AIR 41, p.136, p.87.

	Total	**3998**	**146**	**3.7%**
May-42	Night	2702	114	4.2%
	Day	105	1	1.0%
	Total	**2807**	**115**	**4.0%**
Jun-42	Night	4801	119	2.4%
	Day	196	2	1.0%
	Total	**4997**	**121**	**2.4%**
Jul-42	Night	3914	171	4.4%
	Day	313	19	6.1%
	Total	**4227**	**190**	**4.5%**
Aug-42	Night	2454	142	5.8%
	Day	186	10	5.3%
	Total	**2640**	**152**	**5.8%**
Sep-42	Night	3489	169	4.8%
	Day	127	6	4.7%
	Total	**3616**	**175**	**4.8%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany: 1939-1945,* pp.431-438.

The loss increases following the commencement of area bombing provoked meaningful discussions within the Air Ministry and the Command concerning the formal adoption of ECMs *en masse* to protect aircraft. This triggered the emergence of an embryonic Bomber Command EW policy. In April 1942, Air Chief Marshal [ACM] Charles Portal, the chief of the air staff, decreed that the employment of the WINDOW ECM could be undertaken at Harris' discretion. WINDOW was an ECM designed to produce a multitude of echoes on a radar screen. This was achieved by the dispersal of thousands of strips of aluminium each of which was cut to a length of precisely half the wavelength of the transmission frequency of radar that the ECM was intended to jam. The aircraft would still be visible on a radar screen, but only as one of several thousand individual plots caused by the echoes from the ECM. Portal's order would not see the immediate introduction of WINDOW and instead triggered a spirited debate within the Air Ministry and Command regarding the costs and benefits of its deployment. At this point in the war, WINDOW was intended to jam *Luftwaffe* FC/GCI radars.[17] Jones argued that, by early 1942, Bomber Command had developed an 'obsession' regarding *Luftwaffe* AAA and the damage it could inflict on the Main Force. He believed that the majority of losses were being caused not by AAA but by *Luftwaffe* fighters, which constituted the greatest threat.[18] Nevertheless one consequence of the introduction of WINDOW, which will be seen in the following chapter, was that as FC/GCI radars were also used for controlling fighters, the jamming of these radars would affect the ability of the *Luftwaffe* to vector its aircraft. While the intention of the Air Ministry in April 1942 was to employ WINDOW to degrade radar-guided AAA, the ECM would thus have an impact on the *Luftwaffe* fighter force.

The April 1942 RCM Board meeting provided an tantalising clue as to why the RAF seemed not to have performed large-scale and frequent kinetic attacks against the *Luftwaffe* IADS' radar and radio communications/navigation systems, and C2 centres, instead confining its kinetic efforts in this regarding to 2 Group's attacks against *Luftwaffe* airfields. This was as much to degrade the strength that the *Luftwaffe* could employ against Russia's armed forces, as it was to degrade the *Luftwaffe's* bomber and fighter fleets that could be directed against United Kingdom.[19] Kinetic attack against all the elements of a hostile IADS has become an integral component of the overall OCA battle as witnessed in major air campaigns since the Second World War. Yet evidence is scant that the RAF performed any concerted kinetic effort against *Luftwaffe* radar and radio communications/navigation targets for the entire duration of the conflict, save for efforts to destroy *Luftwaffe* radars along the coast of Western Europe, and in the invasion area prior to, and during, Operation Overlord in June 1944. As these

[17] 'RCM Board. Minutes of the Second Meeting held at Air Ministry, Whitehall on Tuesday, 7 April, 1942', AIR 20/8213.
[18] Jones, *Most Secret War*, p.316.
[19] AIR 41, p.281.

efforts indicated, with hindsight it would seem that, should a similar effort have been mounted against the IADS' electronic elements it would have seriously degraded the contribution that these could have made in support of Germany's overall air defence. Moreover, by the spring of 1942 the RAF was able to recognise *Luftwaffe* ground-based air surveillance and FC/GCI radar, and radio transmitters, and determine their location via photoreconnaissance. However, during the 7 April 1942 meeting the RCM Board's chairman argued that attacking *Luftwaffe* ground surveillance radar positioned on the coast of France could alert the *Luftwaffe* to an imminent Bomber Command attack, hence removing the element of surprise, with the Board agreeing that this course of action should not be pursued.[20] Was this the same reason why the RAF appeared to desist from kinetic attacks against other electronic elements of the IADS? Scant research has been performed by air power historians as regards this question and, while it is worthy of further examination, it remains outside the scope of this thesis.

Jones deepened his knowledge of the *modus operandi* of the *Luftwaffe* IADS as 1942 unfolded. He could see the location of the main searchlight belt positioned along the Kammhuber Line as depicted on a stolen *Luftwaffe* map which had been obtained by the Air Ministry from underground sources in continental Europe. At the same time, the Air Ministry was expanding its knowledge of the disposition of inland *Luftwaffe* radar coverage.[21] As Price noted the expansion of the body of knowledge regarding the workings of the IADS was a result of the intelligence gathering effort *vis-à-vis* the electronic ORBAT.[22] The Air Ministry's deepening knowledge of FC/GCI radar had also been greatly assisted by the audacious Operation Biting raid to capture a FuMG-62D radar located at Bruneval on the

[20] 'RCM Board. Minutes of the Second Meeting held at Air Ministry, Whitehall on Tuesday, 7 April, 1942', AIR 20/8213.
[21] Price, *Instruments of Darkness*, p.78.
[22] Jones, *Most Secret War*, 292.

French Normandy coast on 27 February 1942. This yielded a single FuMG-62D which was transported back to the UK for further examination, providing important clues as to how the radar could be jammed. Harris also observed that the number of GCI stations from which the interception of Command aircraft were controlled increased throughout 1942. Similarly, fighters continued to proliferate, while the searchlights in the main belt were removed and redeployed to likely target areas to both illuminate hostile aircraft and to dazzle aircrew. Harris continued that searchlights diminished in importance as an illumination tool, as an increasing number of fighters were equipped with AI radar.[23] As can be seen in figure VII, losses remained an average of almost four percent during the final three months of 1942.

Figure VII – Bomber Command Losses for Sorties Despatched: October - December 1942

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Oct-42	Night	2198	89	4.0%
	Day	406	14	3.4%
	Total	**2604**	**103**	**4.0%**
Nov-42	Night	2067	53	2.6%
	Day	127	11	8.7%
	Total	**2194**	**64**	**2.9%**
Dec-42	Night	1758	72	4.1%
	Day	200	16	8.0%
	Total	**1958**	**86**	**4.3%**

Source - ‘Appendix 10’ in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-438.

The growing sophistication and potency of the IADS was encouraging research by the TRE. By May 1942 two specific ECMs, Ground Mandrel and Ground Carpet were considered sufficiently advanced for them to be deployed on aircraft and at ground installations as

[23] Harris, *Bomber Offensive,* p.100, p.102.

prototypes. Yet the intended user for these ECMs was not Bomber Command, but Fighter Command which had been tasked with the destruction of *Luftwaffe* fighter strength in Western Europe with the intention of drawing this away from the Eastern Front. Integral to this effort was the requirement to reduce the detection range of FuMG-80 radar to deprive the *Luftwaffe* of early warning time. In this regard the Ground Mandrel ECM, a ground-based transmitter, would broadcast RF transmissions to jam FuMG-80 coastal coverage and reduce this radar's range to 17.3nm (32.18km). The Ground Mandrel ECM would be used in conjunction with the Moonshine airborne ECM to feign a large incoming formation of hostile aircraft, while Ground Carpet would jam coastal FuMG-62D radars. Both the Ground Carpet and Ground Mandrel ECMs were deployed in the vicinity of England's Channel coast to maximise their effect against the hostile radars deployed on the French Channel/Atlantic coast.[24]

While Fighter Command was embracing this trio of ECMs in its OCA campaign against the *Luftwaffe*, Bomber Command continued to rely on concentration to overwhelm the IADS. This tactic, which had been enabled in no small part by the adoption of GEE was yet to have the desired effect of reducing losses. Harris stated that a Main Force of between 250 to 350 aircraft was unable to achieve the necessary concentration to overwhelm the IADS at a particular point and time while ensuring the desired level of destruction. Thus he planned to increase the strength of the Main Force to 1,000 aircraft using the entirety of Bomber Command's strength including training and operational conversion units. The first time that a Main Force of this size was employed was on the night of 30/31 May, when Cologne was

[24] AIR 41, pp.85-86.

attacked. Harris noted that 1047 aircraft were despatched to attack the city, with 900 aircraft dropping 1455 tons of ordnance.[25] Reflecting on the attack, Harris observed that:

> Detailed analysis revealed that the large numbers of aircraft did not prevent the enemy's location devices from selecting and following single targets all through the attack but, owing to the concentration of aircraft, the guns were prevented from engaging more than a very small proportion of the total.[26]

Harris also had to reckon with improvements in *Luftwaffe* fighter tactics in the summer of 1942, notably the tendency of these aircraft to attack a bomber's ventral fuselage at very short range, taking advantage of the habit of bomber aircrew to look across the sky rather than towards the ground for incoming fighters, and the exploitation of the ground as a dark backdrop from which to approach the bomber. While bombers could counter this tactic by initiating a rapid decent using a corkscrew manoeuvre, this by itself was not sufficient to eliminate ventral attack. Harris realised that a more holistic approach could pay dividends, observing that: 'It would be necessary to find means of breaking the extremely efficient control of the night fighters by the ground stations.'[27] This method of control was by the use of R/T and W/T, and FC/GCI radar. The AOC-in-C thus articulated Bomber Command's first tangible EW policy; to engage the C2 of the *Luftwaffe's* fighters; a policy which was a reaction to both the existence of the IADS fighter control system, and to the losses that this was inflicting. Moreover, Harris was displaying Campaign level SEAD thinking: He needed to degrade the potency of the IADS' fighter force to enable his offensive to succeed, taking a long-term view in this regard. Although Harris asserted that his intention to break *Luftwaffe* fighter control was to 'regain tactical superiority over the enemy', it was this tactical superiority which Harris believed would bring him strategic success.

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[25] Grehan, Mace, *Bomber Harris,* p.48.
[26] *Ibid.*
[27] Harris, *Bomber Offensive,* p.100, p.102.

Harris was quick to embrace ECMs as a mechanism to degrade the performance of the fighter force: ‘We knew that any or all of these transmissions, on which the whole ground control of the enemy’s night fighters depended could be jammed, and possibly also the airborne radar carried by night fighters for interception in the dark.’ By the summer of 1942, Harris was lobbying the Air Ministry, and RAF in general, for the development and deployment of ECMs to jam *Luftwaffe* IADS radar and radio communications. Nevertheless, he stated that he was stymied by opponents in the Air Ministry fearful that the application of ECMs, particularly Window, in support of the strategic air campaign could trigger a jamming war with the *Luftwaffe* responding in kind against the RAF Chain Home ground-based air surveillance radar network.[28] Concerns aside, Harris’ arguments received support from a Command ORS report published in August which argued that ECMs could reduce aircraft losses by between 30 percent and 60 percent. Four principle targets underpinning the IADS were identified for the applications of ECMs: the coastal chain of FuMG-80 radars, and their inland counterparts; the FuMG-62D FC/GCI radars; HF ground-to-air/air-to-ground fighter radio communications and *Luftwaffe* AI radar.[29]

As Harris was urging the application of ECMs in support of Bomber Command operations, Fighter Command was bringing its own ECMs into service, notably Moonshine which was used in anger for the first time on 6 August 1942 by Boulton and Paul Defiant-II aircraft of 515 Squadron. These aircraft entered the *Luftwaffe’s* FuMG-80 detection zone in the vicinity of RAF Middle Wallop airfield in Hampshire and then left the zone near Southampton after remaining there for one hour. The Moonshine jamming caused a force of 26 *Luftwaffe* fighters

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[28] *Ibid.*
[29] AIR 41, pp.88-89.

to be scrambled and for the balloon barrage at Cherbourg to be raised, illustrating that the ECM had convinced the IADS that a large group of RAF aircraft was approaching France.[30] While it was employed to protect Fighter Command aircraft, Moonshine was not adopted by Bomber Command. This was because the effect of the ECM was to present radar operators with a simulation of a large formation of aircraft, as opposed to the long continuous stream characteristic of the Main Force, and would thus be unlikely to convince a seasoned *Luftwaffe* radar operator that they were seeing the Main Force on their radar. Secondly, the operation of Moonshine-equipped Defiant-II aircraft at night was considered dangerous, given the flight profiles that the aircraft had to assume and the resulting danger of night time mid-air collision. Bomber Command ruled out the use of Moonshine to protect its aircraft in early November 1942 when ACM Sholto-Douglas, the AOC-in-C of Fighter Command, wrote a letter to the Undersecretary of State for Air articulating his belief that the ECM could not protect Bomber Command operations given the inherent dangers of operating Moonshine equipped aircraft at night:

> The operational application of "Moonshine" by night has been discussed with representatives of Bomber Command, and I formed the impression that they too were dubious as to its use. For this reason … I recommend that the use of "Moonshine" by night be postponed until such time as it is possible to incorporate in a single aircraft a "Moonshine" apparatus capable of covering all the frequencies in use in the enemy Freya band. When this technical improvement has been made, it might be possible to fly aircraft in line astern, at intervals of about five miles, and give the impression of the approach of a bomber raid.[31]

Instead such was the pace of technological development within the TRE at this point in the war that Moonshine was eclipsed by other countermeasures which demonstrated more

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[30] *Ibid.,* pp.192-193.
[31] 'Letter from ACM Sholto-Douglas, Air Officer Commanding-in-Chief, Fighter Command to the Undersecretary of State for Air, 2 November 1942', AIR 2/7609 Radar and Radio Countermeasures (Code B.61): RCM 'Moonshine' and 'Mandrel', 1941-1943.

effective jamming of the FuMG-80 radar, chiefly the Mandrel ECM introduced in December 1942. A further event occurred in the final six months of 1942 which would have a significant effect on Command EW policy and SEAD posture for the rest of the war; the appointment of Air Cdre Edward Addison as chairman of the RCM Board. Addison was 'dual-hatted' as the chair of the RCM Board and the Air Officer Commanding [AOC] of 80 Wing.[32] Addison shared Harris' belief that ECMs could help reduce the Command's losses and, as will be shown in subsequent chapters, he exhibited Campaign level SEAD thinking, arguing that the application of ECMs in support of Bomber Command's offensive was intrinsic to its success. Harris was convinced regarding the potential benefit that ECMs could have in protecting aircraft and, as of September 1942, he had an ally in a key position within the Air Ministry whom could transform his conviction into reality.

October - December 1942: Gathering Momentum

With Addison at the helm of the RCM Board, the caution-induced inertia that had characterised the Command's adoption of ECMs began to change. During the same RCM Board meeting where Addison had been named chair, the decision was taken to install the Mandrel ECM across 20 percent of the Command's bomber force.[33] Furthermore, 515 Squadron's Defiant-IIs were to be equipped with Mandrel, with both Bomber and Fighter Command intending to use the ECM to jam FuMG-80 radars:

> Mandrel could, therefore, be used to blot out the enemy's early warning system just prior to our main bomber force crossing his coast, so as to prevent the enemy from

[32] 'Minutes of 9th Meeting Held at Air Ministry, Whitehall on Tuesday, 22 September, 1942', AIR 20/8213.
[33] *Ibid.*

> knowing in what direction the attack is being routed, and also reduce the early warning he gets of our aircraft approaching his coast.[34]

AM Victor Tait, the RAF's director-general of signals in a letter to Bottomley continued that Mandrel jamming could be employed to screen ingressing and egressing Bomber Command aircraft from radar detection.[35] This concept of operations for Mandrel was an instructive example of Localised level SEAD. Revisiting the Localised SEAD definition, Baltrusaitis stated that this: 'focuses on disrupting, degrading and destroying elements of an IADS in a defined area or during a defined timeframe'.[36] Moreover, Mandrel was a clear example of SEAD being applied in a Manoeuvrist fashion, given its purpose was to shorten *Luftwaffe* early warning times by reducing radar detection range.[37]

While Bomber Command planned to employ Mandrel against FuMG-80 radars it lacked an efficient mechanism to jam FuMG-62D radars beyond the Window ECM, the permission for which to deploy had yet to be granted by the Air Ministry. One means under consideration was to adapt the IFF Mk.I sets with the hope that this could degrade the performance of these radars echoing the practice witnessed during 1941 of switching this equipment on and off in the hope of dowsing searchlights. Given that the Command had determined that searchlights were controlled by FuMG-62D radars, it considered during a meeting held on 6 October 1942 at the Command's headquarters to discuss ECMs for bomber protection, that so-called 'squittering' IFF sets, codenamed Shiver, should be introduced into service as soon as

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[34] 'Tait, M, Director General of Science to Assistant Chief of the Air Staff (Operations) RCM Aids for Bomber Protection, 29 September 1942', AIR 2/7609.
[35] *Ibid.*
[36] Baltrusaitis, *Quest for The High Ground*, p.3.
[37] Bellamy 'Manoeuvre Warfare', p.541.

possible.[38] Like Mandrel, Shiver was an example of Localised level SEAD as it was intended to protect an individual aircraft; as opposed to contribute to the long-term degradation of the IADS, although whether it did provide protection is a matter of debate. Given that the ECM was to be used by the Main Force to jam FuMG-62D radars in its *locale*, Shiver was an example of the Mass application of SEAD, as it was intended to: 'to saturate and overwhelm an air defense (sic) system at a given point'.[39]

The same meeting agreed that Mandrel should enter service with Bomber Command with a target date of 1 December 1942. Although Ground Mandrel ECMs had been installed near Hastings and Dover, on the Kent coast, they had not yet been used operationally, and the meeting agreed that this should not occur until airborne Mandrel ECMs were ready for use to prevent the *Luftwaffe* discovering the jamming and taking remedial action. The Ground Mandrel ECMs were envisaged to have a role in reducing FuMG-80 radar coverage over the channel to assist the masking of Bomber Command aircraft ingressing and egressing hostile airspace.[40] They would be under the command of 80 Wing marking its initial foray into providing ECM assistance to Command operations, and forging a level of support which would continue throughout the war. The measures agreed at the 6 October meeting were subsequently agreed by the Air Ministry on 19 October.[41] After the reluctance of the Air Ministry to commence jamming for fear of initiating a jamming war, the arguments of Harris, the detective work of Jones and the research and development work of the TRE had paid off. Bomber Command was now free to commence using ECMs against the IADS. The summer

[38] 'Minutes of a meeting held at HQ Bomber Command on 6 October 1942 to Consider Radio Countermeasures for Bomber Protection', AIR 2/7609.
[39] Dougherty, *Defense Suppression*, pp.26-27.
[40] 'Minutes of a meeting held at HQ Bomber Command on 6 October 1942 to Consider Radio Countermeasures for Bomber Protection', AIR 2/7609.
[41] AIR 41, p.89.

and early autumn of 1942 had seen Bomber Command adopt a reactive EW policy as it sought to reduce the losses exacted by the *Luftwaffe* IADS. Harris exhibited Campaign level SEAD thinking realising the long term effect that reducing the potency of the IADS' could have on the Command's losses and hence the achievement of the strategic goal of the destruction of German's war-making potential. The Campaign level SEAD thinking which underpinned the authorisation for Bomber Command to commence using ECMs was illustrated in a letter dated 17 October 1942 from Bottomley to Sholto-Douglas:

> I am directed to inform you that a careful study of operational casualties in Bomber Command has shown that recent increases are traceable in part to improvements in the enemy's radio aids to night defence. It has, therefore, been decided that the Air Officer Commanding-in-Chief, Bomber Command, shall employ appropriate radio countermeasures co-ordinated with his offensive operations, with a view to reducing the operational casualty rate in his command.[42]

ECM operations were schedule to commence by 1 December 1942.[43] Shiver was the first such countermeasure deployed albeit with disappointing results. The official history stated that the ECM was popular with aircrews, despite the fact that: 'there was little evidence forthcoming that it was having any appreciable effect on enemy (FC/GCI radar)'.[44] For all intents and purposes, Shiver was the ECM equivalent of a placebo; making crews feel safer, while not affording any tangible protection. To exacerbate matters, the RF energy transmitted by Shiver caused interference for the RAF's Chain Home radar, causing the ECM to be removed from operational use on 19 February 1943.[45]

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[42] 'Letter from AVM Bottomley, Assistant Chief of the Air Staff (Operations) to the Air Officer Commanding-in-Chief, Fighter Command, 17 October 1942', AIR 2/7609.
[43] *Ibid.*
[44] 'RCM Board, Minutes of the 12 Meeting held in Room 11/II Air Ministry, Whitehall, on Tuesday, 15 December, 1942', AIR 20/8213.
[45] AIR 41, p.90.

While Mandrel, Ground Mandrel and Shiver were all aimed at the IADS' ground-based air surveillance and FC/GCI radar, Bomber Command still had to jam *Luftwaffe* R/T and W/T if it was to degrade the ability of fighter controllers to vector their aircraft towards incoming bombers. In the early autumn of 1942, HF R/T and W/T remained a significant threat to the Command. The countermeasure proposed to this end used the Command's T-1154 radio carried by its aircraft. The RCM Board proposed that a total of 20 aircraft would cover the 3MHz to 6MHz waveband with each aircraft covering a band of 150 kilohertz [KHz]. The radio operator would move his tuner through his allotted bandwidth. When HF radio transmissions were detected, he would tune his radio to its frequencies and transmit noise picked up by microphone from the bomber's engine thus jamming the transmissions.[46] Like the introduction of Mandrel/Ground Mandrel and Shiver, the development of this ECM, which would be codenamed Tinsel was a reaction to the threat posed by *Luftwaffe* HF radio. Tinsel was introduced into service on the night of 2/3 December 1942. It was deployed at the Localised SEAD level to protect the Main Force in its specific *locale* during its mission, while applying a Mass SEAD approach as it was intended to perform jamming of *Luftwaffe* HF radio communications in their entirety.

While the Tinsel ECM would be focused on jamming HF communications, work commenced on ECMs to jam *Luftwaffe* AI radar, notably the Ground Grocer device. The realisation of Ground Grocer which commenced service in November 1942 was an important stage in the evolution of the holistic nature of the Command's EW policy. Although the decisions taken during the October meeting were vital in setting the stage for the Command's deployment of ECMs they did not amount to a comprehensive approach to jamming the electronic elements

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[46] 'Minutes of 10th Meeting held at Air Ministry Whitehall on Thursday, 22 October, 1942', AIR 20/8213

of the IADS. While the 6 October meeting took the decision to commence jamming against *Luftwaffe's* ground-based and FC/GCI radar, AI radar and radio communications were largely ignored, leaving two thirds of the IADS' electronic elements undisturbed until the advent of Tinsel in December 1942. AI radar would be the target of the Ground Grocer transmitter, which became operational at Dunwich on the Suffolk coast on 26 April 1943. This was designed to reduce the range of the FuG-202 *Lichtenstein-BC* AI radar to 457.2m (1500ft) when a fighter was at an altitude of 12,000ft (3,657.6m) and 121.6nm (225.2km) from the transmitter.[47] Akin to the other ECMs already discussed, Ground Grocer's introduction was the result of a reactive EW policy as it was a response to the FuG-202 radar. Secondly, the ECM was used to perform Localised level SEAD as it was intended to protect the Command's aircraft for the duration of their mission, while utilising the Manoeuvrist SEAD approach as the ECM reduced the detection range of the radar and hence the response time of *Luftwaffe* fighters.

Although the Command was taking its first tentative steps regarding the employment of ECMs, its ELINT effort to enhance its understanding of the IADS did not diminish. By December 1942 Jones had developed a robust understanding of the size and scope of the IADS, noting that it was now dispersed across a line stretching from Schleswig Holstein in northern Germany to the Franco-Swiss border just north of Basel.[48] By the final month of 1942, Bomber Command had determined that the *Luftwaffe* IADS had adopted a system by which GCI stations would work with two FuMG-65 radars; one to track the fighter and the other to track its target. The proliferation of GCI stations, and accompanying radar, in the latter half of 1942 was a reaction to the Command's exploitation of weakly defended airspace

[47] AIR 41, p.153.
[48] *Ibid.*, p.73.

over occupied Europe for the ingress and egress of their aircraft.[49] By late 1942 this extension of IADS' coverage made it impossible for the Command to ingress and egress without traversing heavily defended airspace. The skill of *General der Flieger* Josef Kammhuber, whom had been placed in charge of overhauling the IADS in 1940, was in realising that attrition, rather than a knock-out blow, could have a seriously adverse effect on the long-term success of the Command's strategic air campaign:

> It would … be impossible for any raid to reach a German target without passing through several nightfighter boxes, both on the inward and outward routes, and each of those boxes would therefore inflict a steady proportion of losses on our attacking bombers. Our night offensive could therefore have developed into a campaign of attrition, in which our losses were never spectacularly high or spectacularly low, but in which the steady toll taken by the closely controlled fighters might ultimately have proved prohibitive.[50]

By the end of 1942, the Command had made three important steps towards countering the IADS: It had taken the decision to jam its electronic elements, commenced the introduction of ECMs to this end and continued to maintaining a comprehensive understanding of the *Luftwaffe* IADS, so as to respond to new radar and radio systems and techniques as and when they appeared. In this respect, the Command's EW policy at this point in the war was wholly reactive. Everitt and Middlebrook argued that the impact of the ECMs introduced by the Command, specifically Tinsel and Mandrel was at first small, with neither countermeasure capable of causing widespread disruption within the IADS, nevertheless they posited that the ECMs were: 'a minor but steady irritant' to the *Luftwaffe*.[51] Their views chimed with those of Harris who stated that the two ECMs had little immediate effect on the IADS.[52] Nevertheless, their introduction was highly symbolic. The losses that the Command had suffered throughout

49 'Note on Enemy Night Air Defence', AIR 14/3246.
50 *Ibid.*
51 Everitt, Middlebrook, *The Bomber Command War Diaries,* p.291.
52 Grehan, Mace, *Bomber Harris,* p.43.

1941 and 1942 underscored the need to protect aircraft to the fullest extent possible if the offensive was not to stop through attrition. Much as Kammhuber had realised that he could not defeat Bomber Command outright by delivering a short series of heavy blows via his fighter force, so the Command realised that it would have to perform methodical and steady jamming of the IADS if it was to preserve the bomber force. The Command's goal was utilitarian in nature; not to save every aircraft, but to save as many as possible for the good of the strategic air campaign.

Nonetheless, while the Command adopted a reactive EW policy from the autumn of 1942, there were examples in late 1942 of proactive EW policies emerging. For example, during a meeting of the RCM Board held on 15 December 1942, Addison reflected on the introduction of Tinsel. He warned that this HF jammer could prompt the *Luftwaffe* to move its radio communications to higher VHF wavebands of 30MHz to 300MHz and that 'we must be ready to jam these'. He added that, at that point in the conflict, there were no suitable airborne ECMs which could jam VHF radio communications. Instead, Addison suggested that the Ground Grocer ECM could provide a useful template, with similar ground-based transmitters being deployed in the UK to jam VHF radio. He proposed that this be done to provide a 'lane' of VHF jamming to protect Bomber Command aircraft during their missions thus using a Localised SEAD approach.[53] Addison's idea was an early example of proactive EW policy: The *Luftwaffe* had yet to switch its radio frequencies to VHF yet this change was already being anticipated by the RAF. As predicted, this would occur by 1943, although as the RCM

[53] 'RCM Board, Minutes of the 12th Meeting held in Room 11/II Air Ministry, Whitehall, on Tuesday, 15 December, 1942', AIR 20/8213.

Committee noted in June 1943, the *Luftwaffe* continued to inhabit the HF waveband for around 50 percent of its radio communications, causing Tinsel to still be necessary.[54]

January - July 1943: Waging the Electronic Offensive

Roosevelt, Churchill and General Charles de Gaulle and General Henri Giraud, the latter both representing the Free French forces, met in Casablanca, Morocco between 14 and 24 January to plan the allied European strategy for the next phase of the war. Overy argued that air power was central to achieving victory, and that the achievement of air superiority would be essential for guaranteeing the success of any Allied invasion of the continent.[55] On the same day that the Casablanca conference commenced, Harris received a directive from Bottomley which stipulated that the Command was to commence area bombing attacks against German U-boat bases in response to: 'the recent serious increase in the menace of the enemy U-boat operations'.[56] This directive was supplemented seven days later with a further directive reflecting the priorities of the Combined Chiefs of Staff (the supreme military staffs of the Western Allies during the Second World War) which continued to prioritise the Command's destruction of U-boat bases, while adding the German aircraft industry as a further priority, thus reflecting the need articulated at Casablanca to achieve air superiority, along with transportation, oil targets and additional unspecified targets associated with Germany's war-making potential.[57] The directive continued that targeting priorities within these criteria may change from time to time, with Berlin added as an objective to be attacked when conditions

[54] 'Proceedings of the Radio Countermeasures Committee. 1st Meeting. 26 June 1943', AIR 20/8508 Royal Air Force: Bomber Command (Code 67/9): Bomber Command RCM Committee: minutes of meetings, 1943-1944.
[55] Overy, *The Air War*, pp.73-74.
[56] '14 January 1943 Directive from Air Vice-Marshall NH Bottomley (Assistant Chief of the Air Staff (Operations)) to Air Marshall Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* p.152.
[57] '21 January 1943. Combined Chiefs of Staff Directive for the Bomber Offensive from the United Kingdom', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.153 and AIR 41/43, p.11.

were judged favourable to have both a psychologically detrimental effect on the Nazi regime while demonstrating solidarity with the Soviet Union.[58] The wish to strike Berlin was reinforced in a further letter from Bottomley to Harris on 16 February, which reflected Red Army tactical successes during Operation Saturn in western Russia/Ukraine and in the Caucuses. The letter articulated a desire: 'to further rub in the Russian victory by further attacks on Berlin as soon as conditions are favourable'.[59] Other additional priorities included targets in Italy in support of Allied amphibious operations in the Mediterranean.[60]

The emphasis on German aviation, transportation and oil plants outlined in the 21 January directive laid the basis for the Battle of the Ruhr which would commence on the night of 5/6 March with the Command attacking Essen. The commencement of the battle was a reflection of how Harris interpreted the 21 January directive which, according to the official history of the Command's strategic air campaign, caused him to note that:

> What this directive really means is that he (Harris) should obliterate Hamburg, Bremen and Kiel as quickly as possible and that when weather does not allow attacks on these cities he should go for others of the highest industrial value, with a preference for those which are important in the U-boat and aircraft industries. Berlin and the Biscay bases are extra.[61]

Harris was emphatic in his faith in the destructive power of area bombing. He argued in his memoirs that not only was area bombing the sole option available to Bomber Command at the time, it was a policy 'which was also the best way of destroying Germany's capacity to

[58] '21 January 1943. Combined Chiefs of Staff Directive for the Bomber Offensive from the United Kingdom', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* p.153.
[59] '16 February 1943. Air Vice-Marshal NH Bottomley (Assistant Chief of the Air Staff (Operations)) to Air Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* p.155.
[60] '21 January 1943. Combined Chiefs of Staff Directive for the Bomber Offensive from the United Kingdom', in Frankland, Webster, *The Strategic Air Offensive Against Germany,* p.153.
[61] AIR 41/43, p.14.

produce war material'. Central to Harris' conviction was a belief in the psychological effect of area bombing which he conceded was an 'imponderable factor' and that 'just possibly a break in morale might lead to the collapse of the enemy', with low morale amongst industrial workers compounding breaks in industrial production caused by material damage. The material damage that the Command could wreak, he asserted, would be sufficient to 'cripple the enemy's war industries if it was carried out for long enough and with sufficient weight'.[62]

The Battle of the Ruhr would rage for almost 100 days with 99 night and 55 day operations being mounted, with 4.3 percent losses sustained. Bowman argued that the majority of these aircraft were destroyed by *Luftwaffe* fighters.[63] The Command had to reckon with an increase in *Luftwaffe* fighter production which was seeing 1,000 single and 200 twin-engine fighters being produced per month from July 1943; double the number being produced in January 1943. To compound matters, the *Luftwaffe* redeployed its fighter strength as the Command's offensive gained momentum in the first half of 1943. For example, in August 1942 30 percent of *Luftwaffe* fighter strength had been concentrated on the Western Front with 43 percent concentrated on the Eastern Front. By April 1943 the Western Front had 45 percent of the fighter strength compared to 27 percent on the Eastern Front.[64] As predicted by Addison in late 1942, the radar and radio communications/navigation systems of the *Luftwaffe* IADS continued to evolve in the face of Mandrel and Tinsel jamming. Initial ELINT gathered in January revealed that the *Luftwaffe* may have moved the frequencies used by the FuMG-80 radar beyond the wavebands jammed by Mandrel.[65] In March, it was discovered that coastal FuMG-80 radars had moved their transmission frequencies to a 124MHz to 127MHz

[62] Harris, *Bomber Offensive*, p.72.
[63] Bowman, *100 Group*, p.14.
[64] AIR 41/43, p.71.
[65] AIR 41, pp.89-90.

waveband, although it was suggested that this may have been to avoid interference from some *Luftwaffe* AI radars.[66] By June ELINT collection had determined that the FuMG-80 radars were transmitting on frequencies of 129MHz, 131MHz and 140MHz. The response of the TRE was to increase an order from 100 to 600 for an American version of Mandrel which could be tuned to a waveband of 85MHz to 140MHz, with orders for an additional 600 versions of the British Mandrel ECM which had been modified with a wider jamming waveband.[67]

Meanwhile, in December 1942 as noted above Addison had suggested that an ECM be developed with similar physical characteristics to Ground Grocer for VHF radio jamming. This resulted in the realisation of an ECM codenamed Ground Cigar. This was designed to jam *Luftwaffe* radio across the 38MHz to 42MHz waveband. Fifteen transmitters would be positioned around the UK with each transmitter responsible for jamming one frequency segment.[68] By the spring of 1943, the TRE estimated that the Ground Cigar ECM would be sufficient to provide a lane of jamming 139nm (257.4km) in length, although later testing in April determined that jamming ranges of up to 182nm (337.9km) could be achieved by an aircraft flying at 18,000ft (5,846.4m).[69] As will be seen later, an aircraft-mounted version of this ECM was developed called ABC. The Ground Cigar ECM commenced operations in April and, like the Ground Grocer ECM upon which it was based in concept if not in target, employed the same Localised level SEAD approach by jamming *Luftwaffe* IADS VHF radio over a defined timeframe to provide a corridor of jamming along Bomber Command's ingress and egress routes. The ECM employed the Mass approach to SEAD as it was intended to jam

[66] 'Minutes of the 15th Meeting Held in Room 11, Second Floor, Air Ministry, Whitehall on Tuesday 9 March, 1943, at 1030 hours', AIR 20/8213.
[67] AIR 41, pp.89-90.
[68] Streetly, *Confound and Destroy*, p.158.
[69] AIR 41, pp.93-94.

VHF frequencies used by the *Luftwaffe* in their entirety, while being an example of both proactive and reactive EW policy; proactive as its development was the result of Addison's anticipation of a frequency shift by the *Luftwaffe* in the wake of Tinsel deployment, and reactive as it was deployed once ELINT collection had confirmed this anticipated frequency shift.

The need for ECMs such as Ground Grocer was becoming all the more apparent during the first six months of 1943. As figure VIII illustrates, the Command was suffering loss rates of 3.7 percent for sorties despatched. While this compared favourably with the losses of 4.7 percent suffered between October and December 1942, and 4.5 percent suffered between January and September 1942, losses remained a cause for concern, particularly in regards to the effort that the Command was now expected to exert against Germany.

Figure VIII – Bomber Command Losses for Sorties Despatched: January - June 1943

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Jan-43	Night	2536	86	3.4%
	Day	406	15	3.7%
	Total	**2942**	**101**	**3.4%**
Feb-43	Night	5030	101	2.0%
	Day	426	6	1.9%
	Total	**5456**	**107**	**1.9%**
Mar-43	Night	5174	161	3.1%
	Day	284	7	2.5%
	Total	**5458**	**168**	**3.0%**
Apr-43	Night	5571	253	4.5%
	Day	316	12	3.8%
	Total	**5887**	**265**	**4.5%**
May-43	Night	5130	234	4.6%
	Day	360	19	5.3%
	Total	**5490**	**253**	**4.6%**
Jun-43	Night	5816	275	4.7%

	Day	0	0	0.0%
	Total	**5816**	**275**	**4.7%**
Jul-43	Night	6170	188	3.0%
	Day	0	0	0.0%
	Total	**6170**	**188**	**3.0%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-438.

This increase in momentum for the Command crystalised with the start of Operation Pointblank on 14 June. The basis for this operation was published on 3 June in the form of the draft directive published by the Combined Chiefs of Staff which would become known as the Pointblank directive. The directive reflected the intention of the Casablanca Conference, and took the subsequent directive issued to Bomber Command on 21 January as its basis. The Pointblank directive recognised increased *Luftwaffe* fighter activity as a consequence of the intensification of the Command's offensive. It stressed that: 'The increasing scale of destruction which is being inflicted by our night bomber force and the development of the day bombing offensive by the Eighth Air Force have forced the enemy to deploy day and night fighters in increasing numbers.' It warned that; 'Unless this increase in fighter strength is checked we may find our bomber forces unable to fulfil the tasks allocated to them by the Combined Chiefs of Staff.' The remedy advocated by the directive was the intensification of the Command's OCA effort against the *Luftwaffe* fighter force and German aviation industry. The destruction of Germany's war-making potential remained unchanged as the directive's priority. While Pointblank stressed that the USAAF Eighth Air Force was to attack *Luftwaffe* fighter strength, the Command was to hit the German aircraft industry, the areas where such targets were located, *Luftwaffe* aircraft storage areas, and the destruction of fighters in the air and on the ground.[70] As Davis-Biddle argued, the OCA dimension of Pointblank would be a

[70] '10 June 1943. Air Chief Marshal NH Bottomley (Assistant Chief of the Air Staff (Operations)) to Air Chief Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.158.

sine qua non for the strategic air campaign, to both ensure its success and that of any future continental invasion.[71]

ECM efforts did not remain static in the Command while the OCA emphasis of the Pointblank directive unfolded. Following the introduction of Ground Cigar in April 1943, ABC began to take shape in June. Confusingly, the ABC ECM was also referred to as Jostle, although for the rest of this thesis, the ABC appellation will be used.[72] The ECM was intended to disrupt hostile VHF radio communications initially across the 38.3MHz to 42MHz waveband with jamming being achievable over a range of 43.2nm (80km).[73] At this stage in the war, the TRE envisaged prototype installations for ABC to commence in mid-July 1943.[74] ABC would be used to perform Localised SEAD, employing a Mass approach, and was the result of a proactive EW policy following Addison's expectation of a frequency move to VHF. Meanwhile, the Command was taking an increasingly formal approach to the drafting and enacting of its EW policy. In late June 1943 it formed the Bomber Command Radio Countermeasures Committee [RCC] with Air Commodore William Theak, Bomber Command's Chief Signals Officer [CSO] as its chair.[75] The RCC was established with the aim of coordinating the work of the Air Staff, Bomber Command's Signals and its ORS to collect and analyse data on how ECMs were being used in support of the Command's

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[71] Davis-Biddle, *Rhetoric and Reality in Air Warfare*, p.217.
[72] C. Ward, G. Harrison, G. Korcz, *I Group Bomber Command: An Operational Record*, (Barnsley: Pen and Sword, 2014), p.83.
[73] Streetly, *Confound and Destroy,* p.154.
[74] 'RCM Board. Minutes of the 17th Meeting Held in Room 11, Second Floor, Air Ministry, Whitehall, on Friday, 4 June, 1943, at 1430 Hours', AIR 20/8213.
[75] 'Proceedings of the Radio Countermeasures Committee, 1st Meeting, June 26, 1943', AIR 20/8508 Royal Air Force: Bomber Command (Code 67/9): Bomber Command RCM Committee: minutes of meetings, 1943-1944.

offensive.[76] The activation of the RCC thus formalised a mechanism by which the Command's EW policy could be supported.

Although Harris had notionally been authorised to employ the Window ECM in April 1942, its use was ultimately postponed until the summer of 1943. Despite Portal granting permission for its deployment Professor Frederick Lindemann, the government's chief scientific advisor, persuaded Portal to rescind the order following tests which illustrated that Chain Home radar was vulnerable to Window jamming, yet by late 1942, these radars, plus the AI radars equipping RAF fighters, had been upgraded to render them immune to Window jamming.[77] The ECM would be used for the first time on the night of 24/25 July during the opening attacks of Operation Gomorrah, the Allied bombing offensive against the northern German port of Hamburg. The results of Window's employment was that losses on the first night of operations were relatively light at around 1.4 percent for sorties dispatched, although the RCM Board conceded that these relatively light losses may not have been due entirely to the deployment of Window. Nonetheless, the Board stated that: 'Window undoubtedly had some effect on the result … There was evidence that the enemy GCI System was disorganised to a great extent.'[78] Days after Window was employed for the first time, the Command activated the Ground Cigar ECM on the night of 30/31 July.[79]

The introduction of Ground Cigar and Window alongside Mandrel, Tinsel and Ground Grocer illustrated that the Command's EW policy was now taking on a distinctly holistic dimension,

[76] 'Notes on a Meeting at HQBC on 19 June 1943 to consider closer staff liaison on the application of Radio countermeasures', AIR 20/8508.
[77] Overy, *The Bombing War*, p.334.
[78] 'RCM Board. Minutes of the 19th Meeting Held in Room 11, Second Floor Air Ministry, Whitehall, on Tuesday, 27 July, 1943 at 1039 Hours', AIR 20/8213.
[79] AIR 41/43, p.88.

seeking to jam as many of the radar and radio communications/navigation systems used by the IADS as possible. Ground-based and AI radar, alongside HF and VHF radio communications were now being routinely jammed. The official reluctance of Bomber Command to embark upon the use of ECMs in the first two years of the war for fear of provoking a jamming war experienced a *volte face* in late 1942 and then gathered momentum as that year came to a close and as the RAF intensified its strategic air campaign as a result of the Casablanca conference and Pointblank Directive. This momentum continued throughout the summer of 1943 as the Air Ministry's scientific expertise sought mechanisms to jam as much of the IADS as possible. In late July Jones advised the RCM Board that *Luftwaffe* fighters were equipped with a radio navigation system which used VHF radio and was known as the Y-System by the RAF. As an example of reactive Bomber Command EW policy, Jones realised that there was a need to develop an RF homing device which could detect Y-System transmissions and that an ECM should be devised to jam these, with the GROUND CIGAR VHF ECM being the most suitable candidate.[80] However, it would be sometime until an ECM to this effect was developed.

Conclusions

The established canon of literature stated that the commencement of the Command's strategic bombing campaign against Germany, and its belief that losses could be reduced by the adoption of ECMs, were two of the motivations for the Command's eventual adoption of an EW policy, as was the Channel Dash of February 1942 and the Command's ill-fated use of IFF Mk.1 equipment to jam searchlight radar control. Such motivations were cited in addition

[80] 'RCM Board. Minutes of the 19th Meeting Held in Room 11, Second Floor Air Ministry, Whitehall, on Tuesday, 27 July, 1943 at 1039 Hours', AIR 20/8213.

to the argument that Bomber Command chose not to implement ECMs for fear of triggering a similar use by the *Luftwaffe* against the Chain Home radar network. Nevertheless, while the literature raises some valid points regarding the motivating factors influencing the Command's adoption of EW policies and ECMs therein, with the exception of the Channel Dash which receives scant mention as a motivation in the official documentation, the literature ignored how the Command was minded to implement its nascent EW policies and fails to explain whether ECMs were to be used to only protect Bomber Command aircraft during their missions over Germany, and/or as an important part of aiding the wholesale destruction of the *Luftwaffe* IADS at large. Furthermore, while stating that EW policy was reactive at this point in the war, the works examining Bomber Command's efforts against the IADS do not provide examples of where the policy was proactive.

In the wake of the *Luftwaffe's* strengthening of its IADS during the first half of 1942 Harris became highly aware of the threat that the former could pose to the successful outcome of the strategic air campaign, which had been growing in size and intensity since the start of 1942. Nevertheless, as Bomber Command intensified its strategic air campaign between January 1942 and July 1943, the Command's losses increased. Harris knew that the key to minimising the risk posed to the Command's aircraft by *Luftwaffe* fighters was to break the C2 element of the IADS, principally its radar and radio communications. In this respect, the Command began to adopt a reactive EW policy *vis-à-vis* the threat it faced from the electronic elements of the IADS. Moreover, Harris' thinking was a direct illustration of the Campaign level SEAD approach as he knew that the potency of the IADS had to be continually degraded if the strategic air campaign was to succeed. He was to receive an ally in the appointment of

Addison as the chair of the RCM Board in September 1942 who would demonstrate similar Campaign SEAD thinking as regards the efficacy of ECMs as the war continued.

In October 1942, the decision was taken for the Command to use ECMs *en masse*. While the thinking of Harris exhibited a Campaign level SEAD approach, the ECMs which the Command would introduce would support Localised SEAD, with countermeasures such as Mandrel and Ground Grocer employing a Manoeuvrist approach, while the Shiver, Window and Tinsel ECMs, also designed to be used at the Localised level, would employ a Mass approach. At this stage in the war, the Command's EW policy was reactive; deploying ECMs in response to the threat posed by the *Luftwaffe* IADS. Yet this period also witnessed examples of proactive EW policy, such as Addison's anticipation of the *Luftwaffe* using higher radio frequencies in the wake of Tinsel's deployment, with his suggestion that the Ground Grocer ECM be used as the basis for a VHF radio jammer to provide Localised level SEAD. This would result in the development of the Ground Cigar ECM which would employ the Mass SEAD approach. This would later be followed by the ABC ECM which would be employed in a similar fashion. With 1942 and the first six months of 1943 witnessing the emergence of coherent EW policies, the stage was now set for the Command's EW efforts to coalesce further with the creation of a dedicated EW unit in the guise of 100 Group; the formation of which will be examined in the following chapter.

CHAPTER FOUR

MAKING THE COMMITMENT: THE *RAISON D'ÊTRE* FOR 100 GROUP'S ACTIVATION

Introduction

Whereas the previous chapter examined the gradual introduction of ECMs into Bomber Command service, and the decision taken in October 1942 to formally allow the Command to use these in anger, this chapter will examine the Command's decision to activate a dedicated ECM force, in the guise of 100 Group in November 1943.

The chapter will note that rising losses in the face of a reorganised *Luftwaffe* IADS during the summer of 1943 was an increasingly concern for the Command's leadership regarding its ability to continue the strategic air campaign. Measures were taken during this time to reduce Command losses such as the introduction of spoof attacks, and changes to Main Force tactics. The chapter will continue by examining the Ground Cigar and ABC ECMs which attained operational strength and entered operational service respectively during 1943. Beyond its examination of these ECMs, the chapter will discuss the criticisms levelled at Fighter Command by Bomber Command's leadership in the summer of 1943 regarding the level of fighter support the latter received during operations over Germany. Such criticism prompted the Command's leadership to lobby the Air Ministry for the creation of a dedicated Group to provide both fighter and ECM protection. The chapter will observe that in the late summer of

1943, the Air Ministry debated 100 Group's activation, ultimately granting permission and stipulating the tasks it was to perform, with the Group being formally activated in November.

July - September 1943: The Summer of Discontent

The Command first used the Window ECM in anger during the opening attacks of Operation Gomorrah on the night of 24/25 July 1943. Overy argued that the repercussions of its use for the IADS were significant. He stated that the *Luftwaffe* abandoned aspects of the Kammhuber Line which stressed the use of searchlights and AAA in favour of increasing its reliance on a greatly enlarged fighter force. Overy continued that, while this overhaul of the IADS had commenced prior to Gomorrah in the face of intensifying Command attacks throughout 1942 and 1943, the bombing of Hamburg acted as the catalyst for its acceleration.[1] Changes to the IADS were also noted by Harris who stated that, in light Window jamming of the IADS' FuMG-62D radars, the *Luftwaffe* increased its reliance on human observers to plot the position of the Main Force with fighter controllers then transmitting a running commentary on the bomber's location to an airborne force of fighters orbiting a radio beacon, with controllers providing the height, bearing and possible target of the former. Once the target had been discerned the orbiting force of fighters was vectored towards the target where searchlights redeployed from the Kammhuber Line would illuminate the bombers, or illuminate the cloud base in the hope of silhouetting the bombers above it, or via the use of flares dropped by fighters over the target.[2] The consummate effect of this reorganisation, Harris noted, was a rising loss level which was a cause for concern:

[1] Overy, *The Bombing War*, p.334.
[2] Harris, *Bomber Offensive*, p.146.

> We were once again getting very near the danger line when expansion would be seriously affected unless the losses could be cut down … however great might be the strategic effects of our operations, it would be impossible to maintain the offensive unless something was done to cut our losses down.[3]

The toll which the IADS was able to exact on Bomber Command during the period under examination in this chapter is illustrated in figure IX, which states that average Bomber Command loss rates for sorties despatched increased to 3.5 percent in August, September, October and November, compared to the three percent losses sustained in July:

Figure IX – Bomber Command Losses for Sorties Despatched – July-November 1943

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Jul-43	Night	6170	188	3.0%
	Day	0	0	0.0%
	Total	**6170**	**188**	**3.0%**
Aug-43	Night	7807	275	3.5%
	Day	0	0	0.0%
	Total	**7807**	**275**	**3.5%**
Sep-43	Night	5513	191	3.5%
	Day	0	0	0.0%
	Total	**5513**	**191**	**3.5%**
Oct-43	Night	4638	159	3.4%
	Day	0	0	0.0%
	Total	**4638**	**159**	**3.4%**
Nov-43	Night	5208	162	3.1%
	Day	0	0	0.0%
	Total	**5208**	**162**	**3.1%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Thus Harris was more than aware of the danger that any increase in loss rates could pose to the overall success of the strategic air campaign. One measure adopted was to attempt to

[3] *Ibid.*

dilute the response of the *Luftwaffe's* fighters to any attack by the Main Force by introducing the 'feint' or 'spoof' tactic which sought to lure these fighters away from the Main Force. This was a tactic which remained in use until the end of the war. Such tactics took two forms; firstly the seemingly erratic routing of the Main Force by which its apparent target could only be discerned at the latest possible moment before the attack commenced. Secondly a diversionary force, usually comprised of De Haviland Mosquito fighter-bombers would accompany the Main Force for most of the ingress towards the intended target and shortly before this was reached, it would then leave the Main Force to attack a diversionary target. This was intended as much to force the *Luftwaffe* IADS to divide its fighter strength as it was to confuse the *Luftwaffe* as to the Main Force's intended target. In addition to the spoof tactics other adjustments were made to Main Force tactics, notably an increase in the density of bombers crossing over the target at any given time from a total of ten per minute to up to 30 per minute. Such a course of action was not risk-free and increased the danger of bomber collisions, and aircraft being hit by falling ordnance. Harris observed: 'we decided to accept the greater risk from collision and falling bombs because by escaping the enemy fighters we should save far more aircraft than we lost'.[4]

Alongside the adoption of such tactics, the Command continued to expand its use of ECMs, such as Ground Cigar developed as proactive response at the urging of Addison, in his capacity as chair of the RCM Board, in December 1942. He recommended the development of the ECM in anticipation of the *Luftwaffe* moving their radio transmissions into the VHF waveband of 38MHz to 42MHz following the commencement of HF jamming in the 3MHz to 6MHz waveband with Tinsel in that same month. Although the ECM had commenced

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[4] *Ibid.*

operation in April 1943, by 30/31 July, a total of fifteen Ground Cigar transmitters had been constructed around southern England and were jamming the 38MHz to 42MHz waveband in its entirety.[5] As noted in Chapter Three, Ground Cigar was designed to provide a 'lane' of jamming and was only to be used when the Main Force was active.[6] As such it was an example of SEAD being performed at the Localised level.[7] At the same time, the ECM employed the Mass approach to SEAD as it was intended to overwhelm the IADS, chiefly its VHF radio frequencies, in the Main Force's *locale*.[8] Like the Ground Cigar ECM ABC, designed to jam *Luftwaffe* radio communications across the 30MHz to 33MHz, 38.3MHz to 42.5MHz and 48MHz to 52MHz VHF wavebands was to be used at the Localised SEAD level to apply Mass.[9] This ECM would be carried by the Lancaster-BI/III heavy bombers of 101 Squadron, with several aircraft deployed during each Bomber Command operation carrying the ECM and providing jamming for the Main Force for the duration of its mission.[10]

Furthermore, the Command had to react to changes in the IADS which were themselves a reaction to Bomber Command's jamming. For example, with the deployment of Window during Operation Gomorrah, the *Luftwaffe* placed a heavier emphasis on using its FuMG-80 ground-based air surveillance radars which, despite now being used to track individual bombers, did not have the accuracy of the FuMG-62D radar. This new concept of operations caused a corresponding intensification of the use of the Mandrel ECM which had been introduced by the Command to degrade the performance of the FuMG-80 in December 1942. Yet the intensification of Mandrel's use from August 1943 caused a corresponding increase in

[5] Streetly, *Confound and Destroy*, p.158.
[6] 'Minutes of a Meeting held 14 August 1943 at Headquarters Bomber Command, to consider the Operational Application of Airborne Cigar', AIR 20/8508.
[7] Baltrusaitis, *Quest for The High Ground*, p.3.
[8] Dougherty, *Defense Suppression*, p.25.
[9] Streetly, *Confound and Destroy*, p.154.
[10] 'Minutes of a Meeting held 14 August 1943 at Headquarters Bomber Command, to consider the Operational Application of Airborne Cigar', AIR 20/8508.

casualty levels for aircraft equipped with this ECM. Thus by late August 1943, the Command had three airborne ECMs in service; Tinsel, Mandrel and Window (with ABC entering service on the night of 7/8 October 1943) all of which 'provided collective rather than individual security'.[11]

This ever-present need to reduce bomber losses received added impetus in the summer of 1943. The Quebec/Quadrant conference had been held in the eponymous Canadian city between 17 and 24 August involving the American and British governments. The conference primarily focused on Allied plans to invade continental Europe. The results of these discussions manifested themselves in the 3 September directive sent from Bottomley to Harris which stressed the continued destruction of Germany's military, industrial and economic targets and the disruption of communications. Echoing the Pointblank Directive discussed in the previous chapter, the 3 September directive emphasised the need to continue the; 'material reduction of German air combat strength by the successful prosecution of the Combined Bomber Offensive … (as) a prerequisite to Overlord (the Allied invasion of Western Europe)'. The destruction of the *Luftwaffe's* air power, the directive added, was to 'have the highest strategic priority'.[12] While the directive placed a priority on destroying the *Luftwaffe*, Harris bemoaned what he believed to be inadequate fighter cover provided to the Command. Writing to Harold Balfour, the Undersecretary of State for Air four days before the issuing of the directive, on 31 August he was critical of the support which the Main Force and Bomber Command in general had received to date from Fighter Command during missions over Germany:

[11] 'Notes on the use of Airborne Countermeasures', AIR 20/8508.
[12] '3 September 1943, Air Marshal N.H. Bottomley (Deputy Chief of the Air Staff) to Air Chief Marshal Sir Arthur Harris, in Frankland, Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Vol. IV: Annexes and Appendices*, p.160.

> The minute effort which is all that is at present devoted to the night fighter operations arranged by Fighter Command are a welcome assistance to our bombers in their flight to and from their targets. They do not, however, go nearly far enough.[13]

Harris used the example of the Command's attack of Berlin on the night of 23/24 August to illustrate the contribution that support from Fighter Command might have made:

> If, for instance, it had been possible to send our night fighters over Berlin during our attack on the night of August 23/24, there can be no doubt that they would have been able to shoot down a number of German night fighters, and the resulting interference in the enemy's defence organisation would have saved us many casualties in the bomber force.[14]

Harris also levelled criticism at Fighter Command's Intruder operations against *Luftwaffe* airfields which had commenced in May 1942. These OCA missions, he argued, 'have been so restricted by the lack of aircraft considered suitable for this role that they have so far contributed very little'.[15] Ultimately he argued that, so long as the fighter defence of its aircraft remained the responsibility of Fighter Command, the protection provided to the Main Force would be lacking:

> It is not unreasonable to conclude that air offensive actions, on the scale required to give fair prospects of success against the German defence system, is unattainable so long as the responsibility for developing and increasing this action remains with Fighter Command whose primary and essential function is something entirely different, namely the ensuring of the defence of Great Britain against any probable scale of enemy air attack.[16]

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[13] 'Letter from AVM Harris to Undersecretary of State for Air 31 August 1943', AIR 20/4715, Bomber Command 100 Group Papers.
[14] *Ibid.*
[15] *Ibid.*
[16] *Ibid.*

Harris' parting shot to Balfour was to argue that the IADS was too robust to suffer from the levels of support given by Fighter Command to protect the Main Force, stating that: 'The defences of Germany are far too powerful and well organised to be dealt with as a side issue.' In the same letter Harris proposed his solution, which was to transfer Fighter Command's Intruder and night fighter squadrons to Bomber Command, where they would be deployed in a 'Group whose specific duty it would be to conduct co-ordinated offensive measures in support of bomber operations'. He added that a total of four night fighter and two Intruder squadrons would be sufficient to support the Main Force. In his letter to Balfour Harris articulated his expectation that the IADS would increase in size and lethality as Bomber Command continued its attacks against German targets in the future.[17] His proposal was met with opposition from some quarters of the Air Ministry, which would make the final decision on any permanent transfer of Fighter Command squadrons to Bomber Command, principally from Air Cdre. Ronald Ivelaw-Chapman, the Air Ministry's director of policy. In a 6 September letter written to Bottomley, Chapman stated his position as against;

> the proposal of (Harris) because it is based on the thesis that a C-in-C [Commander-in-Chief] must have under his direct operational control all the air forces which contribute in any way to the achievement of his strategic directives. This to my mind is wrong and would in itself form a precedent for putting under C-in-C Coastal Command such fighter forces as are at present at his call for anti-shipping escorts, and under the US 8th Air Force such fighter forces as co-operate in their daylight attacks on Germany.[18]

Chapman's proposed solution was to maintain the *status quo*, with Fighter Command continuing to provide squadrons to perform missions in support of Bomber Command but to force the AOC-in-C of Fighter Command, AM Trafford Leigh-Mallory and Harris to co-

[17] *Ibid.*
[18] 'Memo from Director Of Policy to ACAS (Ops) Proposed Transfer of Night Fighters and Intruders to Bomber Command, 6 September 1943', AIR 20/4715.

operate more closely to improve the quantity of fighter protection offered to Bomber Command. This could be achieved, Chapman added, by compelling Leigh-Mallory to release some of Fighter Command's squadrons on any given night from their duties of protecting the United Kingdom against *Luftwaffe* attack so as to protect the Main Force.[19]

September - November 1943: The Growing Need

Harris was not only concerned about adequate fighter protection for his aircraft. In a further letter sent to the Air Ministry dated 7 September 1943, he argued that a large-scale ECM effort must be prepared against the IADS fighter force, radar and radio communications/navigation systems, in the form of barrage jamming. Harris observed that the Window ECM had been used with discernable effect against FuMG-62D radars which the IADS employed to control the interception of bombers by AAA and fighters. However, he argued that Window had shortcomings, principally that it was ineffective in protecting aircraft flying in the top layer of the Main Force, and that it also had no effect against FuMG-80 radars. Although as noted above this could be mitigated by the use of Mandrel. To further complicate matters, Harris argued that the quantity of Window which would need to be carried by Main Force aircraft, and the rate at which it would have to be discharged by the aircrew could make it unsuitable for protecting Main Force operations deep into Germany. In late August, Harris' argued for a number of dedicated aircraft equipped with ECMs which could perform jamming against the *Luftwaffe* IADS in its entirety, and in this respect echoed arguments Addison made in July 1943 regarding the development of dedicated ECM-equipped aircraft. Harris stated that these aircraft should be organised into a specific Group, alongside a dedicated fighter component, with the intention of countering the radar and radio

[19] *Ibid.*

communications/navigation systems of the IADS, and its fighter force, effectively providing a holistic approach to the threat posed to the Command's aircraft.[20]

In urging its activation, Harris argued that the Group could have clear consequences for the overall success of Bomber Command's strategic air campaign: He acknowledged that detaching several squadrons from Fighter Command could increase the United Kingdom's susceptibility to *Luftwaffe* attack, yet he countered, perhaps unsurprisingly given the priorities of the Pointblank directive, that Bomber Command's continuing operations against Germany were the 'best possible insurance against any such renewal', of *Luftwaffe* attacks *en masse* against the UK. Harris posited that this goal would be achieved: 'only if the Bomber Offensive is supported to the full'.[21] The activation of a dedicated ECM Group to protect the Main Force against the IADS in its entirety would be instrumental in providing this support, allowing the Command to maintain its pressure on Germany, and to prevent the *Luftwaffe* from resuming strategic attacks against the UK. The official paper *Support of Offensive Air Operations* reinforced the importance of the ECM Group in supporting Main Force efforts by stressing the importance which the *Luftwaffe* IADS attached to radar and radio communications/navigation systems, particularly during night operations: 'The success of the enemy's night defences turns almost entirely on the efficiency of his Radar and his fighter control communication system,' the paper stressed.[22] Ultimately, Harris believed that a specialist combined ECM and fighter group should be raised to create a single unit capable of engaging the *Luftwaffe* IADS in a holistic fashion to support the Command's efforts:

[20] AIR 41, pp.142-143.
[21] 'Letter from AVM Harris to Undersecretary of State for Air 31 August 1943', AIR 20/4715.
[22] 'Support of Offensive Air Operations, 1943', AIR 20/4715.

> There are strong arguments for including within this Group a radio countermeasures Squadron (sic) responsible for offensive operations against the German R/T system on which the enemy's controlled night fighters are largely dependent.[23]

Regarding Bomber Command's EW policy, Harris' recommendation for the activation of such a force showed proactive and reactive characteristics: On the one hand, the policy for employing dedicated ECM aircraft was a reaction to radar and radio communications/navigation systems already in use with the IADS. However, Harris' recommendation was also proactive as he expected that dedicated ECM aircraft would be needed to provide accommodation for future ECMs to jam future IADS radar and radio communications/navigation systems or tactics as and when they were discovered. Harris' thinking regarding the activation of a dedicated ECM and fighter group was an evolution of the Campaign level SEAD thinking he had exhibited since becoming AOC-in-C of the Command in February 1942, and his realisation that the strategic air campaign could only continue with a concerted SEAD effort against the *Luftwaffe* IADS. As we are reminded by Baltrusaitis' definition of Campaign SEAD, this works to 'progressively disrupt, degrade and destroy an adversary's IADS across the entirety, or across a large proportion of, the theatre of operations'.[24] In pressuring for the activation of the Group, this was clearly what Harris had in mind.

Although Harris played a major role in lobbying for the activation of a dedicated ECM Group under the Command's control, he had support from AVM Victor Tait, the Air Ministry's director general of signals. While Harris was concerned with combining fighter protection with dedicated ECM-carrying aircraft to engage the *Luftwaffe* IADs, Tait foresaw potential in combining airborne and land-based ECMs; the latter under the control of 80 Wing with both

[23] 'Letter from AVM Harris to Undersecretary of State for Air 31 August 1943', AIR 20/4715.
[24] Baltrusaitis, *Quest for The High Ground*, p.3.

being employed against the IADS. Such an arrangement, Tait argued, would be instrumental in ensuring the efficient use of resources available to the Air Ministry for the development and application of ECMs not only in support of the strategic air campaign, but also for other elements of the British and Allied armed forces which might need to employ EW in the future. The solution Tait advocated had strong similarities to those posited by Harris in his late August letter, recommending in a 11 September memorandum sent to Bottomley, 'the establishment of a new formation, under which all airborne jamming or radio counter-measures would be carried out'.[25]

The issue regarding the activation of a new dedicated ECM Group was discussed at a meeting held at the Air Ministry on 29 September 1943. The meeting was chaired by Bottomley in his capacity as DCAS, who stated that the Air Ministry had decided that the time had come 'to establish a separate formation to undertake air offensive action against the enemy's (IADS)', with the formation's remit including 'all forms of radar and radio counter-measure operations both ground and air'. Bottomley stated that the new ECM Group would control 'the operational employment of all (countermeasures)' and that it could collect all intelligence relevant to its remit, 'examine results and enable our resources to be exploited to the maximum effect'. Furthermore, AVM Robert Saundby, the deputy AOC of Bomber Command, told the meeting that the size and complexity of the ECMs carried by Main Force aircraft had steadily increased since their introduction in October 1942. The net result of this was that it was increasingly 'necessary to allot special aircraft and units for the (jamming) task since the required technique was outside the scope of the ordinary Bomber crew'. Saundby added that the increasing complexity of the ECMs developed in response to the

[25] 'Memo from DC of S to ACAS (Ops), 11 September 1943', AIR 20/4715.

introduction of new radar and radio communications/navigation systems and techniques, themselves a result of Bomber Command's application of ECMs, could be addressed by the activation of a single group solely tasked with applying EW against the IADS. During the meeting, Bottomley articulated Harris' request that a number of Fighter Command squadrons should be placed under Bomber Command's control to accompany and protect the Main Force. Bottomley added that these squadrons should be formed into a group 'whose specific role would be to conduct co-ordinated offensive action in support to the bomber offensive against the German night defence system', and that the operational control of these squadrons should be exercised by Bomber Command. In making this recommendation, Bottomley dismissed arguments which posited that the redeployment of some Fighter Command squadrons to Bomber Command's control could have an adverse effect on UK air defence. He argued that there was no suggestion that this course of action would have such detrimental consequences, stating that a group combining fighters and specialist ECM-equipped aircraft under Bomber Command's control would have flexibility as a key advantage in that 'if the occasion arose, (the Group) could be utilised for the defence of this country or for example, in support of land operations on the Continent'.[26]

There was a consensus at the meeting that a single organisation should be formed for the employment of ECMs and 'other countermeasures' (i.e. fighters) against the *Luftwaffe* IADS with the organisation applying ECMs and fighter protection for Bomber Command, and collecting intelligence relevant to its mission. The meeting ultimately recommended that 'a centralised organisation for the operational employment of radio and other countermeasures

[26] 'Minutes of a Conference Held on Wednesday 29 September, 1943', AIR 20/4715.

both ground and air, to the enemy's defence organisation should be set up to assist the air offensive'.[27]

The 'centralised organisation' which would be formed as a result was to have five objectives as articulated during the meeting: to exercise operational and administrative control over RAF units employing 'radio means for operating against the enemy's radio systems and systems of air defences', essentially *Luftwaffe* radar, and radio communications/navigation systems and night fighters. Allied to this task, the group would coordinate the employment of all ECMs used by Main Force aircraft against the *Luftwaffe* IADS. Furthermore, the group would control RAF units employing ECMs against radio communications used by hostile land forces, and control the application of ECMs against *Luftwaffe* radar and radio communications/navigation systems, while also controlling the Counter-Radio Development Unit tasked with the realisation of new ECMs, and ECM tactics and techniques.[28] The objectives of the Group were further expanded in mid-October 1943, with a document entitled *Notes on the Countermeasures Group* which stipulated that its activities should include the collection of so-called 'Y Information' ELINT to inform the strategy for the development and deployment of ECMs, and to interpret the reaction of the *Luftwaffe* IADS once a particular ECM had been deployed.[29] This intelligence would be fed back into 100 Group to inform the development of future ECMs and improve the performance of existing ECMs as they were being applied against the IADS. A letter from Albert Rowe, chief superintendent of the TRE to the Air Ministry stressed that alongside the support of Bomber Command's offensive, the Group should be tasked to provide EW support to the USAAF day bombing campaign against

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[27] *Ibid.*
[28] *Ibid.*
[29] 'Notes on the Countermeasures Group 13 October 1943', AVIA 7/2303, RCM Jamming Group Policy.

Germany which had commenced in the spring of 1943, and to future amphibious and land operations.[30]

During the 29 September meeting Bottomley agreed that the new Group was to assume all tasks for directing ECMs against the IADS, including the collection of relevant intelligence, and that the Group was to receive fighters to defend the Main Force. During the meeting, Saundby cited concerns regarding the size and complexity burden which the ECMs required to protect Command aircraft were expected to assume in the future. He continued that this growth in complexity was the result of changes adopted by the *Luftwaffe* IADS in a bid to neutralise the jamming efforts already being pursued by Bomber Command. In this sense, Saundby was advocating a proactive EW policy, in that Bomber Command must activate the Group to anticipate future changes in the *Luftwaffe* IADS as the Command adopted new jamming tactics and techniques. In this case the decision to activate the Group was an example of Bomber Command following a proactive EW policy, as it would be expected to prepare for, and counter, future radar and radio communications/navigation systems as they entered service with the IADS, as well as existing systems. Ultimately the 29 September meeting agreed to create 100 Group, tasking it with employing ECMs against the *Luftwaffe* IADS, controlling the application of ECMs by the RAF in support of land operations, and the research and development of existing and future ECMs. Moreover, the new group would be tasked to provide EW support during daylight bombing missions by the USAAF. Nevertheless, the overriding task for the Group would be the deployment of ECMs against the *Luftwaffe* IADS, in particular its fighter defences.[31]

[30] 'Equipment for Special Jamming Squadrons, 24 October 1943', AVIA 7/2303.
[31] 'Minutes of a Conference Held on Wednesday 29 September, 1943, at Air Ministry, Whitehall, to discuss proposals for the Formation of a Combined Radio Countermeasures Organisation for the Support of the Air Offensive', AIR 20/4715.

November 1943: The Activation of 100 Group

On 8 November 1943, the Air Ministry ordered the activation of the Group, to be called initially 100 (Bomber Support) Group and later 100 Group. 100 Group was placed under the command of Addison.[32] In terms of administration, the Group was under the operational and administrative control of Bomber Command, but under the general technical direction of the Air Ministry. What this meant in practice was that Tait would oversee the technical development of the ECMs and other electronic subsystems which 100 Group would employ, while the Group's operational employment would be the responsibility of Bomber Command's leadership exercised through Addison.[33]

100 Group had five key missions; '(to give) direct support to night bombing or other operations by attacking the enemy night fighters in the air, or ground installations'. Beyond the kinetic mission of the Group's fighter effort, it was to 'employ airborne and ground (ECM) apparatus to deceive or jam enemy radio navigation aids, enemy radar systems and certain enemy wireless signals'. The group also had an intelligence collection role which stressed its investigation of 'the offensive and defensive radar, radio navigation and signalling systems of the enemy', so as to aid kinetic and ECM attacks against the *Luftwaffe* IADS in the future. This process of intelligence collection would help to build a 'body of Intelligence … for use in future operations (as a means of disorganising) enemy offensive and defensive radio systems'.[34] Beyond the expansion of its tasks regarding Y Information relating to the behaviour of the IADS, a memorandum from Saundby to the Air Ministry on 13 November

[32] AIR 41, pp.145-146.
[33] 'Role and Function of No. 100 (SD) Group, AVM Walmeley, SASO, Bomber Command 21 March 1944', AIR 2/7309, Radio Counter-Measure Organisation, Role and Functions of No.100 (SD) Group.
[34] *Ibid.*

1943 stressed the importance that 100 Group was to place on jamming the *Luftwaffe* IADS' radio communications:

> Every method of night fighter control depends ultimately on passing instructions from the ground to the fighter by R/T … If these vital links were effectively cut night fighters would have nothing to assist interception except AI [radar]. The jamming of communications and of AI therefore rank highest in priority and with these two systems rendered ineffective night fighters would be virtually powerless.[35]

This destruction of the *Luftwaffe* IADS C2 capabilities was to be enhanced by the Group performing direct kinetic attacks against *Luftwaffe* IADS radio communications, presumably transmitters or Ground Controlled Interception stations, although this level of specificity is not evident in the *Notes on the Countermeasures Group* document.[36] While the Group's kinetic mission in this regard would merit further study, as it has received scant attention in the existing literature, alongside the group's collection of Y Information, these two aspects of its activities will not receive additional examination in this thesis as they do not directly relate to the Group's prosecution of EW. This was also the case for 100 Group's employment of fighters to protect the Main Force which were ostensibly performing kinetic, as opposed to EW, actions.

Finally, the Group was tasked to collect and examine information regarding the employment of *Luftwaffe* fighters 'so that the tactics of the bomber force may be immediately modified to meet any changes'.[37] Intelligence collection was a vitally important part of 100 Group's mission to allow it to adapt to changes in the *Luftwaffe* IADS as and when they occurred as a result of the Group's actions. The document *Notes on the Countermeasures Group* stressed

[35] 'BC/MS 30829/Sigs Development of Radio Countermeasures Equipment', AIR 20/4715.
[36] 'Notes on the Countermeasures Group, 13 October 1943', AVIA 7/2303.
[37] 'Role and Function of No. 100 (SD) Group, AVM Walmeley, SASO, Bomber Command 21 March 1944', AIR 2/7309.

the importance of detailed intelligence and argued that: ‘Only with such a picture can Bomber Command strategy be fully effective and the enemy’s weaknesses be exploited by jamming, diversions and confusion and intrusion activity.’[38] Alongside its protection of Bomber Command operations, 100 Group was tasked with providing assistance to USAAF daylight bombing operations, and future combined operations executed from the United Kingdom.[39] This last point is particularly instructive as 100 Group would play an important role suppressing the *Luftwaffe* IADS during Operation Overlord. With the Air Ministry having taken the decision on its formation, 100 Group officially became part of Bomber Command on 24 November 1943.[40]

Conclusions

Regarding the period leading up to, and including, the formation of 100 Group in November 1943, several volumes have focused on the efficacy of the Window ECM. Moreover, a number of works have examined the reasons for 100 Group’s activation, such as the need to slow the losses being suffered by the Command, particularly in light of the expansion of the strategic air campaign, as well as a need to reduce aircrew workloads *vis-à-vis* the ECMs they were now required to operate in addition to pursuing their mission. Other motivations for the Group’s activation included the physical and numerical growth of ECMs throughout the Command, and the challenge of accommodating these on bombers, plus the logistical burden that ECM research, design, development and production imposed upon both the Air Ministry and RAF. Additionally, the need to gather ELINT as well as previous RAF experience

[38] ‘Notes on the Countermeasures Group, 13 October 1943’, AVIA 7/2303.
[39] ‘Role and Function of No. 100 (SD) Group, AVM Walmeley, SASO, Bomber Command 21 March 1944’, AIR 2/7309.
[40] ‘Formation of No.100 Special Duties Group, Communiqué from EB Addison, AOC No.100 (SD) Group, 11 December 1943’, AVIA 7/2303.

regarding EW during the Battle of the Beams were posited as factors behind the activation of 100 Group, as was the ending of the Command's policy of radio silence as it began to employ the GEE navigation system during its missions. Yet the secondary sources examining Bomber Command's efforts against the *Luftwaffe* IADS omitted any discussion of its long-term vision of 100 Group's role. Arguments therein posited that the Group was raised as the result of a reactive EW policy, yet the literature neglects to specify whether the 100 Group's activation was also the consequence of a long-term desire to degrade the potency of the *Luftwaffe* IADS; a goal of both Harris and Addison. Moreover, the literature fails to provide a detailed account of senior level decision-making concerning the Group's establishment. Ultimately, the literature tells us why the Group was activated, but conveys little of the deliberations which resulted in its activation.

During the first six months of 1943, Harris remained Campaign SEAD minded in his approach to the threat posed by the *Luftwaffe* IADS. He was painfully aware that the losses the latter could exact posed a tangible threat to his ability to continue the strategic air campaign at a similar, let alone a higher, intensity. In this regard the need to suppress the radar and radio communications/navigation systems of the *Luftwaffe* IADS were in themselves a *sine qua non* for the strategic air campaign's success. Nevertheless, the ECMs which were evolving during this period, such as Ground Cigar and ABC were to be deployed at the Localised SEAD level using the Mass approach. Despite the introduction of these ECMs, Harris continued to display his Campaign SEAD thinking, in evidence since February 1942, regarding the need to suppress the *Luftwaffe* IADS. He was unwavering in his conviction that the suppression of these air defences was a prerequisite for the success of the strategic air campaign. The decision to activate 100 Group taken in September 1943 was the physical manifestation of Harris' Campaign SEAD intentions. Moreover, it was an example of both reactive and proactive EW policy; reactive in the sense that the Group's creation was a response to the continuing threat posed by the *Luftwaffe* IADS to the Command's strategic air campaign, and proactive as illustrated by Saundby's position that the Group's activation must provide an organisation which could anticipate changes to the IADS as new ECMs and ECM tactics and techniques were devised. As the following chapter will illustrate, while the decision to form 100 Group was an example of both proactive and reactive EW policy and Harris' Campaign level SEAD thinking, initial Group activities would be primarily restricted to fighter operations, as it struggled to wage EW against the IADS with the strength and vigour desired by Harris and Addison.

CHAPTER FIVE

BOMBER COMMAND'S ELECTRONIC WARFARE POLICY AND SUPPRESSION OF ENEMY AIR DEFENCE POSTURE: NOVEMBER 1943-MAY 1944

Introduction

The formation of 100 Group in November 1943 represented a major development regarding Bomber Command's EW policies and subsequent SEAD posture. As this chapter will show, the Group was formed at a juncture in the war when the Command's losses were increasing. This increase was due to the tactical ingenuity which the *Luftwaffe* had increasingly exhibited from July 1943, following the first use of the Window ECM. The *Luftwaffe's* tactical ingenuity was addressed, this chapter will note, using kinetic means, and also new ground-based ECMs which entered service during this phase of the war such as Dartboard, Drumstick, Fidget and Rayon. The chapter will state that these countermeasures were intended as a riposte to the *Luftwaffe's* use of radio navigation and radio beacons for fighter control, as was the Command's adaptation of the ABC ECM to counter this same threat. Unsurprisingly, the *Luftwaffe* IADS did not remain static and underwent a major reorganisation between late 1943 and early 1944 which resulted in its increased centralisation. This centralisation resulted in continued high loss rates for the Command. Bomber Command's response, the chapter will note, was to commence the introduction of squadrons of heavy bombers converted into dedicated EW aircraft with the intention of jamming *Luftwaffe* radar and radio communications/navigation systems. By the end of the period under examination in this chapter, these aircraft would be deployed with the ABC, Carpet and Mandrel ECMs.

November 1943 – January 1944: The Battle of the Beams Redux

Although 100 Group had been activated in early November 1943, the composition of its order of battle occurred in a piecemeal fashion and it would not be until 18 January 1944 when its headquarters would be activated at Bylaugh Hall in Norfolk.[1] A few days following the Group's formation, on 13 November 1943, a letter from Saundby to Balfour provided a detailed description of the assistance Bomber Command expected 100 Group to provide to the strategic air campaign. Saundby's letter began by reflecting that: 'The experience of the past twelve months has shown beyond doubt the confusion, disorganisation and delay which the vigorous use of countermeasures can cause in the operation of the enemy's defences.' He added that: 'There is also no doubt that their use has resulted in a considerable reduction in effectiveness of the large forces now ranged against the bomber offensive.' However, Saundby conceded the difficulty which the Command faced in delivering a decisive blow, electronic or otherwise, against the IADS stating that: 'As each countermeasure is introduced so its antidote is immediately sought by the enemy, necessitating an extension of our effort to deal with the enemy's new organisation.' Saundby thus argued that the Command was condemned to enact reactive EW policies due to the tactical ingenuity exhibited by the IADS: 'While the initiative in changed organisation must rest with the enemy, it is essential that we should keep our counter organisation as nearly as possible up to date with the enemy's changes.' To this end, Saundby stressed the importance of the development, employment and

[1] 'Royal Air Force 100 Group Summary of Events December 1943-April 1944', AIR 20/9037, Royal Air Force: Groups (Code 67/31): 100 Group: Organisation.

modification of ECMs to keep pace with the *Luftwaffe's* initiative, his arguments reflected Campaign level SEAD intentions.[2] Like Harris, Saundby believed that the success of the strategic air campaign was dependent upon the long term attrition of the IADS to keep the Command's losses at a manageable level.

Figure X – Bomber Command Losses for Sorties Despatched: November 1943 - July 1944

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Nov-43	Night	5208	160	3.1%
	Day	0	0	0.0%
	Total	**5208**	**160**	**3.1%**
Dec-43	Night	4134	164	3.7%
	Day	0	0	0.0%
	Total	**4134**	**164**	**3.7%**
Jan-44	Night	6319	310	4.9%
	Day	0	0	0.0%
	Total	**6319**	**310**	**4.9%**
Feb-44	Night	4345	191	4.4%
	Day	45	0	0.0%
	Total	**4390**	**191**	**4.4%**
Mar-44	Night	9133	273	3.0%
	Day	18	0	0.0%
	Total	**9151**	**273**	**3.0%**
Apr-44	Night	10090	208	2.1%
	Day	10	**0**	0.0%
	Total	**10100**	**208**	**2.1%**
May-44	Night	11683	270	2.3%
	Day	16	**0**	0.0%
	Total	**11699**	**270**	**2.3%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Saundby's arguments were made against a backdrop of mounting Command losses. As figure X illustrates, these rose from 3.1 percent of the sorties despatched for November 1943, to 3.7

[2] 'Letter from Saundby to Undersecretary of State for Air: Development of Radio Countermeasures Equipment, 13 November 1943', AIR 20/4715.

percent by December 1943 and 4.9 percent by January 1944. As previous chapters have illustrated, the *Luftwaffe* displayed ingenuity regarding the tactics employed by its IADS, notably reducing its reliance on FuMG-62D FC/GCI radars in the wake of Bomber Command deploying the Window ECM for the first time in July 1943. As Harris noted the *Luftwaffe* took to deploying its fighters to target bombers as they entered the airspace over occupied Europe as opposed to intercepting the bombers when over their targets, or during their return flight. These fighters were despatched from radio beacons around which they would orbit as and when the Main Force ingressed. Moreover, *Luftwaffe* fighters would be directed to the flares dispersed by Bomber Command's Pathfinder aircraft which were tasked to help the Main Force reach its target, with *Luftwaffe* fighters using these flares as a means for discerning the latter's location. One solution to this was to use De Havilland Mosquito fighter-bombers to disperse flares and route markers in the hope of confusing *Luftwaffe* fighters, although route marking was eventually dispensed with altogether with the advent of the H2S airborne ground-scanning radar in 1942, which by late 1943 was proliferating throughout the bomber fleet, providing a radar-based means by which aircrews could detect their targets.[3]

While these increasing losses underscored the operational need for 100 Group, as matters stood at the Group's activation in November 1943, it was commencing its mission from a position of weakness. The IADS remained in a near-constant state of tactical change which greatly complicated the ability of the Group, and the Command as a whole, to stay abreast of developments, and to adapt their tactics accordingly. Geographically, 100 Group had to contemplate employing both fighters and ECMs across a significant area of territory which

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[3] Harris, *Bomber Offensive*, p.156.

not only included Germany, but much of occupied Europe. As the Group's *Review of Operations* for the period under discussion explained, this 'made it very difficult to see what would be the most effective disposition of (the Group's) limited fighter force for maximum Bomber Support'. The review continued that the efficiency of the *Luftwaffe's* FuMG-80 ground-based air surveillance radar network was continually improving thus affording *Luftwaffe* fighters more time to get airborne to intercept Bomber Command's aircraft. At the kinetic level which, although not the focus of this thesis, was a key mission of 100 Group, a number of different fighter tactics were contemplated to enhance the defence of Bomber Command's aircraft. These included fighters patrolling the Command's target areas before and after an attack; having fighters positioned at *Luftwaffe* fighter assembly points such as the beacons discussed above, the position of which was derived from Y-Service ELINT traffic pertaining to the behaviour of enemy aircraft observed on previous raids, and providing protection through the direct fighter escort of the Main Force.[4]

Alongside kinetic efforts, EW played a major role in Bomber Command's battle against *Luftwaffe* fighters, given the reliance that the latter placed upon electronic systems to aid their detection and engagement of the Command's aircraft. 80 Wing was already employing the Ground Grocer and Ground Cigar ECMs to counter *Luftwaffe* AI radar and VHF radio respectively, plus the Corona ECM, introduced in November 1943 against *Luftwaffe* HF radio. Nevertheless, in early November the Y-Service detected a powerful Medium Frequency [MF] transmitter operating on frequencies of 300KHz to 3MHz in Stuttgart, southern Germany which was being used to convey instructions to *Luftwaffe* fighters. These fighter control radio communications were interspersed with normal civilian broadcasts, with

[4] AIR 14/2343, 100 Group Review of Operations, November 1943 to May 1944.

identical instructions being broadcast simultaneously using HF and VHF transmissions so as to widen the number of sources from which radio communications to *Luftwaffe* fighters could be broadcast, and to increase the number of RF sources which the RAF would be required to jam. These MF transmissions were countered using the transmitter at the British Government Communications Centre in Crowborough, East Sussex code-named Aspidistra. This transmitter broadcast continuous noise with the intention of jamming these *Luftwaffe* MF transmissions with the Dartboard ECM (also codenamed Light-Up), which was first used in anger on the night of 6/7 December.[5] The deployment of Dartboard was a reaction to the use of the Stuttgart transmitter and was deployed for Localised SEAD. In this case, Dartboard was employed when specific Bomber Command operations were performed.[6] Moreover, as the jamming was intended to completely block MF transmissions, the Dartboard ECM was an example of the Mass application of SEAD as it was saturating and overwhelming an air defence system at a given point, namely the origin of the transmissions.[7] The jamming was reportedly effective in causing the *Luftwaffe* to abandon this method of transmitting fighter instructions after a short time.[8]

Notwithstanding the activation of Dartboard in early December, and the activation of 100 Group one month earlier, Overy argued that, despite the initial success of the introduction of Window in July 1943, the tactical flexibility exhibited by the *Luftwaffe* in response resulted in the electronic battle between Bomber Command and the *Luftwaffe* being more evenly matched as 1943 drew to a close.[9] He continued that Window was electronically outflanked by the *Würzlaus* ECCM which was added to FuMG-62D radars; the former was used to

[5] AIR 41, p.138, pp.139-139.
[6] Baltrusaitis, *Quest for The High Ground*, p.3.
[7] Dougherty, *Defense Suppression,* pp.26-27.
[8] Grehan, Mace, *Bomber Harris*, p.276.
[9] Overy, *The Bombing War*, p.370.

discriminate the faster-moving bomber dispersing Window from the slower speed of the ECM once it was outside the bomber.[10] Overy continued that approximately 1500 FuMG-62D radars were thus modified in Germany by the end of 1943.[11] Yet, despite the advent of *Würzlaus*, Window was not dispensed with altogether and, as subsequent chapters will state, continued to be used up to the end of the war. While the *Würzlaus* ECCM afforded a degree of assistance to FuMG-62D radar operators the continued use of Window suggested that the *Luftwaffe* was never quite able to completely neutralise the potency of this ECM. Moreover, that the *Luftwaffe* tried to neutralise this ECM is of no surprise. At its heart, EW is a 'cat and mouse' affair with any ECM having at best a finite life span as the adversary examines the ECM's *modus operandi* so as to develop a robust ECCM.

Beyond the ground-based FuMG-62D and FuMG-80 radars which assisted the *Luftwaffe* IADS both to locate Bomber Command aircraft, and to perform the ground-controlled interception of these aircraft, the Command had to contend with *Luftwaffe* AI radar. Radar warning receivers such as Serrate and Monica, both introduced in June 1943, assisted RAF fighters escorting the Main Force to locate and engage their opponents by detecting radar emissions from AI radar, however, both these countermeasures were passive, and could not jam the AI radar used by the *Luftwaffe* fighters.[12] Their role was to assist the fighter to perform a kinetic interception, as opposed to jamming the hostile AI radar. As this thesis is concerned with Bomber Command's EW efforts against the IADs as opposed to its kinetic efforts therein, these ECMs will receive no further examination.

[10] *Ibid.* and G. Galati, *100 Years of Radar* (New York: Springer, 2015), p.111.
[11] Overy, *The Bombing War*, p.370.
[12] Streetly, *Confound and Destroy*, p.166.

Alongside its FuMG-62D and FuMG-80 radars, and the AI radars equipping its fighters, by the end of 1943, the *Luftwaffe* had employed a number of radio navigation systems to direct its fighters towards the Command's aircraft, notably the Benito and Ottokar systems. From December 1943, ELINT had been gathered regarding the existence of a *Luftwaffe* radio navigation system for fighters transmitting across a 31.1MHz to 32.2MHz VHF waveband codenamed Ottokar.[13] Ottokar employed the VHF *Knickebein* transmitter at Den Helder in the northern Netherlands.[14] *Knickebein* had been in use with the *Luftwaffe* from the start of the war primarily to provide radio navigation to bombers performing attacks on the UK, yet it was now employed to help guide fighters towards Bomber Command aircraft. While Dartboard was concerned with jamming fighter control, the Rayon ECM was introduced in January 1944 using a transmitter located on the Norfolk North Sea coast at Mundesley.[15] Rayon was intended to jam the *Knickebein* and Ottokar radio navigation systems and was deployed to perform Localised SEAD, jamming Ottokar RF transmissions in their entirety during Bomber Command operations hence applying Mass.[16] Ottokar was not the only radio navigation system the Command had to contend with. It was supplemented by the Benito system transmitting on a 38MHz to 42MHz VHF waveband. Initially developed as a 'blind bombing' system by which bombers could be vectored towards their targets, Benito was also employed to direct *Luftwaffe* fighters towards hostile aircraft.[17] In January 1944, one solution to Benito was found by the TRE via the modification of the ABC ECMs. This solution was achieved by modifying some of the ABC ECMs used by 101 Squadron to jam Benito. 101 Squadron sorties with the modified ABC ECM, which was fitted across six of its aircraft,

[13] AIR 14/2343.
[14] 'Enemy Night Fighter Control: The 31.2Mc/s Raid Reporting Frequency Lorenz Beam OTTOKAR', AIR 14/3246.
[15] AIR 41, p.137.
[16] Streetly, *Confound and Destroy*, p.160.
[17] AIR 20/8070, Glossary of Code Names and Other Terms Used in Connections with RCM, p.1.

commenced on 27 January 1944.[18] The concept of operation called for the squadron to continue operating its ABC ECMs with the intention of jamming *Luftwaffe* fighter VHF radio communications, while the six aircraft would add Benito jamming using ABC to their *repertoire*, deploying it in a Localised fashion to protect the Main Force during its operations, applying Mass to comprehensively jam the Benito frequencies.[19] Interestingly, 101 Squadron was never incorporated into 100 Group, and the author cannot find any explanation as to why this was the case. However, this may have been because the aircraft used by 101 Squadron were capable of performing their ABC ECM jamming while also carrying ordnance, and were hence able to continue to maintain a kinetic role, as well as to perform EW.

The *Luftwaffe* did not remain static in the face of radio communications/navigation jamming, and as a consequence, in late 1943 it increased its dependence on 3MHz to 6MHz W/T communications for fighter control. This increasing reliance on W/T betrayed the effectiveness of the Command's jamming of voice R/T while creating challenges for *Luftwaffe* fighter aircrew as orders were now required to be passed in code from GCI centres, received by the fighter, decoded by its radio operator and then relayed to the pilot, thus slowing down the process of fighter control. For the Command, this was a double-edged sword as such communications were more difficult to jam compared to R/T as any spoof W/T communications must resemble the keying speed and Morse code tone of the targeted communications to prevent the *Luftwaffe* radio operator discerning genuine and false W/T traffic. A countermeasure in the form of Drumstick was devised in the form of ground-based transmitters in the UK which would transmit meaningless dots and dashes to confuse *Luftwaffe* radio operators, entering service on the night of 21/22 January 1944. Like other

[18] AIR 41, p.135.
[19] AIR 20/8070, p.3.

ECMs examined in this chapter, this countermeasure was deployed in a reactive fashion at the Localised level, utilising a Mass approach. Yet even this application of Mass at the Localised level was insufficient to jam the entirety of *Luftwaffe* W/T transmissions, and the reaction of the force was to increase the spread of the W/T HF frequencies it used to such an extent that it became impossible for Drumstick to counter all of those which were in use at any one time. Nevertheless, the fact that the *Luftwaffe* sought to increase the number of HF W/T frequencies it was using in the face of Drumstick jamming was arguably a reflection of the ECM's success.[20]

Interestingly, VHF ECM jamming instituted by Bomber Command in the form of the Ground Cigar countermeasure designed to jam *Luftwaffe* VHF R/T communications in the 38MHz to 42MHz waveband, introduced in April 1943, and the activation of ABC, designed to jam a 38MHz to 52MHz waveband prompted the *Luftwaffe* to commence R/T communications in lower VHF frequencies notably of 31.2MHz.[21] Harris noted that three ABC ECMs were modified to perform unmonitored jamming on this frequency in January 1944 and that this was done, 'not so much in the hope of obliterating any traffic that there might have been as to indicate to the enemy our readiness to engage him if he continued his developments in that direction'. The use of ABC in this respect was a clear example of both proactive and reactive EW policy; although the Command initiated ABC jamming as a reaction to the *Luftwaffe's* use of the 31.2MHz VHF frequency, the Command was also warning the force against any further use of similar comparatively low VHF frequencies, demonstrating a willingness to

[20] Grehan, Mace, *Bomber Harris*, p.281.
[21] *Ibid.* and Streetly, *Confound and Destroy,* p.154.

extend jamming therein. As Harris observed: ‘This tactic may have been successful, for traffic on this frequency was heard for only a short while afterwards.’[22]

January - May 1943: The Force Awakens

While Bomber Command had been continuing its offensive against German military, industrial, economic and communications targets as per its 3 September 1943 directive, which also stressed the destruction of *Luftwaffe* air strength as a prerequisite for the success of Operation Overlord, the Command’s targeting priorities were to change once again in early 1944. On 14 January Bottomley issued a directive to Harris which acknowledged the continued primacy of the June 1943 Pointblank directive, and stated that the Command was ‘to direct its operations, as far as is practicable, against industrial centres associated with those industries for precise attack by the American bomber forces’. Like the 3 September directive, the 14 January directive stressed the Command’s responsibility for the attrition of *Luftwaffe* air power emphasising that the German ‘air frame and ball bearing industry’ must be targeted to this end, with the effort to be directed against the southern German city of Schweinfurt and the ball bearing factories contained therein. In addition, the directive emphasised the destruction of towns associated with fighter production, notably Augsburg, Brunswick, Gotha and Leipzig.[23] A further directive issued on 28 January reiterated the effort that the Command was to direct against the German aircraft and ball bearings industries. This was to be done so as to ‘ensure the best possible use of the short time before Overlord’.[24] The priority of the strategic air campaign on the German aircraft industry received increased emphasis in a

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[22] Grehan, Mace, *Bomber Harris*, p.281.
[23] ‘14 January 1944. Air Marshal N.H. Bottomley (Deputy Chief of the Air Staff) to Air Chief Marshal Sir Arthur Harris’, in Frankland, Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Vol. IV*, p.161.
[24] ‘28 January 1944. Air Ministry to Bomber Command’, in Frankland, Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Vol. IV*, p.162.

directive issued by the Air Ministry to Bomber Command on 17 February. The Command's overall priority continued to be 'the progressive destruction and dislocation of German military, industrial, economic system (sic)' and communications, and German fighter strength. However, within this mission, the directive continued that the primary objective of the Command was to be the *Luftwaffe*, notably the destruction of fighter strength via the attack of single and twin engine airframe manufacture, airframe component manufacture and ball bearings production as a first priority with the destruction of *Luftwaffe* fighter installations being the second. This was to be achieved through the attack of 'precision targets and industrial areas and facilities' where such targets were located.[25]

As noted above in figure X, in spite of the introduction of new ECMs during the period under review in this chapter, Bomber Command losses continued to maintain comparatively high levels of 4.9 percent and 4.4 percent total losses as a percentage of sorties despatched in January and February 1944 respectively. These increases in losses occurred in tandem with a reorganisation of the IADS. *Generaloberst* Hans Jeschonnek, the *Luftwaffe's* chief of the general staff, had received consistent criticism from *Reichsmarschall* Hermann Göring, the head of the *Luftwaffe*, over its ability to reduce the intensity of the strategic air campaign. Jeschonnek subsequently committed suicide on 19 August 1943 and was replaced by *Generaloberst* Günther Korten who became chief of the general staff and was committed to strengthening the *Luftwaffe* IADS, notably its fighter defences, as opposed to directing this effort towards supporting Germany's land operations. This was followed in November 1943 with the removal of Kammhuber, who had been so influential in the development of the IADS during the first two years of the war, and who was transferred to command *Luftflotte* 5 in

[25] '17 February 1944. Air Ministry to Bomber Command', in Frankland, Webster, *The Strategic Air Offensive Against Germany: 1939-1945, Vol. IV*, p.164.

Norway in the wake of *Generalfelmarschall* Erhard Milch's decision to cancel the procurement of the Heinkel He.219 *Uhu* night fighter which did nevertheless enter service in June 1943. The reorganisation saw *Generalieutnant* Joseph Scmid take command of *Jagdkorps* 1 (1st Fighter Corps), responsible for the defence of western and central Germany, with this unit expanding from a single fighter wing in January 1943 to eleven wings and twenty fighter groups by early 1944. Meanwhile, in December 1943, *Generaloberst* Hubert Weise, was replaced as the commander of *Luftflotte* 5 by *Generaloberst* Hans-Jürgen Stumpff, with *Luftflotte* 5 subsequently being renamed as *Luftflotte Reich* (Reich Air Fleet). In addition *Luftflotte Reich* was made responsible for the air defence of Germany against the strategic air campaign, with the all elements of the IADS placed under *Luftflotte Reich's* control by February 1944. This resulted in the IADS' total centralisation and vastly improved the *Luftwaffe's* coordination of the battle during Main Force operations.[26]

Harris' response to the increased threat posed by the loss levels that the revitalised IADS was capable of inflicting on the Command was to change Bomber Command's tactics once more. Although Harris had overseen a change in tactics in 1943 which resulted in the introduction of spoof attacks, seemingly erratic routing by the Main Force and changes to its density, in February 1944, he took the decision to split the Main Force. What this meant in practice was that the Main Force would be divided into two parts enabling two different targets to be attacked, or a single target to be attacked using two streams converging on the target from different directions. In both cases, the intention was to force the IADS to divide its fighter force. Alternatively the same target could be attacked by two streams but with a time interval between them; with the first stream engaged by *Luftwaffe* fighters which would then have

[26] Overy, *The Bombing War*, p.361.

returned to their bases by the time the second stream arrived to continue the attacks. Moreover, as the *Luftwaffe* had correctly discerned that attacks by the Command's Mosquito fighter bomber force were frequently spoofs, Harris took the decision to ensure that any diversionary operations also included a heavy bomber force to increase the confusion as to any given night's intended target, as well as employing heavy bombers from operational training and conversion units to fly across the North Sea towards the enemy coast and then to turn back at the last moment so as to cause the *Luftwaffe* to track these aircraft and to scramble fighters; all in a bid to dilute the effort which the *Luftwaffe* was able to direct against the bombers attacking that night's intended target. In addition, changes were made to routing to approach targets from France and southern Germany, where the IADS was assessed to have less strength compared to those air defences encountered in the north and west of Germany.[27] As Harris stated:

> The essence of the new tactics was variety; it was important to use as many methods of confusing the enemy as possible and to see that no one of these methods was used too frequently or for too long a time.[28]

These tactical changes took sometime to yield tangible results. During a Bomber Command attack against Stuttgart on the night of 15/16 March, the *Luftwaffe's* fighter force was split in two. One group was sent to engage the bombers *en route* to their target, while a second was held over northern Germany before being ordered to engage the bombers over Stuttgart once the Command's target became apparent. Both a diversionary raid performed by Mosquitoes against Munich, and the routeing of the Main Force to ingress on a southern vector from the United Kingdom towards Stuttgart failed to deceive the *Luftwaffe*, with 4.2 percent of the Main Force being lost to *Luftwaffe* fighters. The losses suffered during the raid on Stuttgart

[27] Harris, *Bomber Offensive*, p.156.
[28] *Ibid.*

were further compounded at the end of March, when the south-eastern German city of Nürnburg was attacked with the Command sustaining its highest level of bomber losses during the Second World War for a single night's operation: from a force of 700 aircraft participating in the attack, 106 were either shot down or crash landed on their return. The Nürnburg disaster led to a further revision of Bomber Command tactics. On 1 April, Harris ordered that ingresses and egresses to and from the target should be increased in complexity and varied often to confuse *Luftwaffe* fighter defences as much as possible, while at least two or more targets should be attacked during any given night of operations to sow as much confusion into the *Luftwaffe's* fighter defences as possible.[29]

Much as Harris was adopting a reactive stance in his reorganisation of Bomber Command tactics in the face of high losses as a result of the reorganisation of the *Luftwaffe's* IADS, the reactive nature of Bomber Command's EW policy was increasingly evident as 100 Group's activities intensified throughout late 1943 and early 1944. For example, the second meeting of Bomber Command's RCM Policy and Progress Committee proposed several courses of action regarding the IADS, in particular its fighter force, and the countermeasures, both electronic and kinetic, which could be brought to bear. Held on 2 February, the meeting agreed for 100 Group's 192 Squadron to commence ELINT gathering flights to acquire intelligence regarding the operating frequencies being used by early warning radars at that point in the war to detect and track incoming Bomber Command aircraft.[30] In fact, 192 Squadron would play an important role as an ELINT-gathering unit. The squadron comprised Vickers Wellington-BX and Halifax-BII/III/V medium and heavy bombers which had been converted to perform ELINT using initially the Bagful system which would record RF signals being received by the

[29] AIR 41/56, p.32, p.34.
[30] 'Minutes of the Second Meeting on Radio Countermeasures Policy and Progress held at Bomber Command on 2 February 1944', AIR 20/8508.

aircraft, particularly hostile radar signals. An enhanced ELINT system, known as Blonde, would later be fitted to these aircraft to provide a visual image of the signals received, rather than recording them on paper. Moreover, Blonde could be used in either a ground-based or airborne configuration.[31] Thus the work of 192 Squadron would be vital for refining the tactics and techniques regarding the ECMs which 100 Group and Bomber Command could employ against the IADS, and for the research, design and development of future ECMs to be employed to this end. This element of the Group's activities were vital to its overall efforts against the IADS' radar and radio communications/navigation systems which the Group's leadership was aware could only be tackled using a holistic approach by bringing a diverse range of ECMs to bear therein.[32]

Also vital to 100 Group's ELINT collection tasks were the activities of the BSDU [Bomber Support Development Unit]. While 192 Squadron was tasked with the collection of ELINT, the BDSU was to:

> (K)eep pace with the ever increasing tempo of the night war (because Bomber Command) cannot always afford to await the new apparatus now under development at research establishments. We require to produce 'lash-ups' (rapidly-designed and prototyped ECMs) quickly in order to keep our radio countermeasures in step with the enemy's tactical and scientific developments.[33]

The BDSU was formed in April 1944 at RAF Foulsham in Norfolk.[34] Its activation was one of several measures taken by Bomber Command to deepen its understanding of the *modus operandi* of the *Luftwaffe* IADS. 100 Group's intelligence section was tasked to provide a

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[31] AIR 20/8070.
[32] AIR 14/2343.
[33] 'Memo from Headquarters No. 100 Group to Headquarters, Bomber Command, 3 February 1944', AIR 14/1062, Bomber Support Development Unit number 100 Group, February 1944-August 1945.
[34] 'Part 1: Story of 100 Group Night Fighters: The Enemy Night Defence System when 100 Group was formed', AIR 14/2911, 100 Group Review of Operations, November 1943-May 1945.

detailed account of *Luftwaffe* fighter activity to Bomber Command's leadership, and the effect of ECMs employed therein. The Command would then circulate this information to its Group headquarters to enable the Groups, and the Squadrons under its command, to plan the tactics they would use to frustrate the IADS during the following night of operations. 100 Group's intelligence would be supplemented by Y Service ELINT, and through the activation of 100 Group's Intelligence Plotting Room which would depict enemy fighter reactions to Bomber Command's activities on any given night to enable a near-real time portrayal of the air battle, with the aim of both anticipating fighter behaviour that night, and to gather data to examine ways in which 100 Group, and Bomber Command's tactics in general could be continually honed.[35] Intelligence-gathering would be a dominant part of 100 Group's activities, as 'The main purpose of finding out what the enemy is doing is to stop him doing it, or at least to put all possible obstacles in his way.'[36] The *rationale* behind 100 Group's ELINT collection effort and the activation of the Intelligence Plotting Room were manifestations of both Campaign and Localised level SEAD: Although both these activities were intended to help support the Main Force on any given night, they were also intended to contribute to the long-term degradation of the *Luftwaffe* IADS to bolster the strategic air campaign's chance of success.[37]

Alongside its ELINT collection efforts via the BDSU and 192 Squadron, the Group strove to enhance its airborne EW capabilities during the first half of 1944, principally via the incremental activation of a force of converted heavy bombers which could engage *Luftwaffe* IADS radar and radio communications/navigation systems as dedicated EW aircraft. During the first six months of its operation, 100 Group was essentially a fighter force, supplemented

[35] AIR 20/9037.
[36] AIR 14/2344, No. 100 Group: report of activities, December 1943-April 1944.
[37] Baltrusaitis, *Quest for The High Ground*, p.3.

by an ELINT gathering effort, in the form of the BSDU and 192 Squadron, and a single airborne EW unit in the form of 214 Squadron which is discussed in more detail below. Up to the formation of 100 Group in November 1943, regarding airborne ECMs, the Command had at its disposal the Lancaster-BI/IIIs of 101 Squadron equipped with the ABC ECM which was first used in anger in October 1943; the Window ECM which had been first used on 24/25 July 1943 and was dispersed by bombers throughout the Main Force; the Mandrel ECM introduced in December 1942 was carried by several aircraft per Command squadron as was the Tinsel ECM, which was also first employed that same month.

The enhancement of the Group's airborne EW capabilities was a direct reflection of Harris' Campaign level SEAD intentions which he had advocated in the summer of 1942 and, as of April 1944, was being advocated by Addison. Writing to Air Cdre. Leslie Dalton-Morris, Bomber Command's CSO, on 17 April 1944, Addison envisaged the role that 100 Group could play in Bomber Command's overall efforts to support the strategic air campaign. In his letter, Addison outlined several aspects of what he referred to as '(t)he general plan for the counter offensive'. This general plan called for the use of 'the cover of darkness' to attack enemy fighters when taking off, flying and landing. These efforts would be joined by spoof raids on targets with the intention of drawing *Luftwaffe* fighters into battle, alongside air-to-ground attacks on enemy airfields. Regarding this effort's EW component, Addison urged that jamming should be used to the full to continue to deceive, degrade and destroy the electronic elements of the IADS. He felt that the short-term effect of these efforts would be 'the wearing down of the Huns by coaxing them to fly on as large a scale as possible even on nights when the 'heavies' are not operating'.[38] Over the longer term, Addison felt that this 'wearing down of the Huns' would be to cause:

> wear and tear on (*Luftwaffe*) aircraft and expenditure of flying hours; by the casualties caused by our fighter action; and by the inevitable crashes that accompany big scale night fighter landing operations when (RAF) intruders are about.[39]

It is clear from Addison's letter that his thinking in terms of how Bomber Command and 100 Group's efforts against the *Luftwaffe* IADS could develop in the future reflected Campaign SEAD intentions: While Addison's vision placed a heavy emphasis on kinetic attack, both air-to-air and air-to-ground, which is beyond the scope of this thesis, his emphasis on jamming as part of this vision illustrated that his thinking regarding the application of EW in support of overall Bomber Command SEAD efforts followed Campaign SEAD level principles.

Thus the development of the 100 Group jamming force would be integral to making Addison's vision a reality. During the timeframe under discussion the Group would commence operations with its first heavy EW unit, 214 Squadron, based at RAF Sculthorpe in Norfolk in support of the Main Force on 20/21 April using Fortress-BII/IIIs equipped with the ABC, Mandrel and Carpet ECMs.[40]

Beyond its jamming of Benito as discussed above, ABC found additional utility as a countermeasure which could supplement the Rayon ECM in jamming Ottokar transmissions. To this end, in late December 1943 Bomber Command took the decision to equip six of the Fortress-BII/IIIs of 214 Squadron with a version of ABC which would operate in the 30MHz

[38] 'Letter from Addison to Air Commodore L. Dalton-Morris, Command Signals Officer, HQ Bomber Command, 17 April 1944', AIR 14/2657.
[39] *Ibid.*
[40] AIR 14/2344.

to 42MHz waveband range directed against Ottokar.[41] These aircraft were intended to supplement and enhance the work of 101 Squadron.[42] In late-January 1944, a meeting of Bomber Command's Radio Countermeasures Policy and Progress committee detailed the tasks that the Fortress-BII/III aircraft thus equipped would perform. They would be evenly spaced across the upper levels of the Main Force to provide overlapping jamming protection, and would perform jamming up to 34nm (18km) to and from the enemy coast, and continuously while the Main Force was over enemy territory.[43] By mid-April 1944, the six Fortress-BII/III aircraft equipped with the modified ABC ECM were ready to commence sorties.[44] Like other ECMs examined in this chapter, the decision to deploy the ABC ECM to protect the Main Force was a reflection of Localised level SEAD thinking, as well as a clearly reactive EW policy drafted in response to the *Luftwaffe's* deployment of the Benito and Ottokar radio navigation systems. Moreover, the intention to deploy the ABC ECM in this regard was to apply Mass SEAD as the ECM was intended to jam OTTOKAR frequencies in their entirety.

During the third meeting of Bomber Command's RCM Policy and Progress committee Saundby noted a proposal from Bomber Command that a dedicated Mandrel squadron should be formed consisting of aircraft configured to deploy ECMs against the entire frequency band of 70MHz to 200MHz used by the FuMG-80 radars. These would be used to mask the movements of the Main Force from these radars, and to assist diversionary operations

[41] 'Development of 100 (SD) Group: RCM Group Fortnightly Report, Bottomley to CAS, 24 January 1944', AIR 20/1568, RCM 100 Group Formation, July 1944-August 1945.
[42] 'No. 100 (SD) Group Fortnightly Progress Report No. 76, for fortnight ending 10 May 1944', AIR 14/2348, No.100 (SD) Group: Fortnightly Progress Reports, March 1944 to November 1944.
[43] 'Minutes of the Second Meeting on Radio Countermeasures Policy and Progress held at Bomber Command on 2 February 1944', AIR 20/8508.
[44] 'Memo from Bottomley (DCAS) to Chief of the Air Staff, 29 May 1944', AIR 20/1568.

performed by 100 Group and Bomber Command in general.[45] The concept of operations for these aircraft called for them to perform jamming to mask the movements of the Main Force from the FuMG-80 radars, and of any diversionary raids performed by Bomber Command.[46] The Fortress-BII/III aircraft of 214 Squadron would assume this role. While the deployment of these aircraft exemplified Localised SEAD, given that they would be used to protect the Main Force during its operations, the deployment of their Mandrel ECMs was an example of the Stealth/Surprise method of SEAD application. Although Dougherty defined this as the use of an aircraft with a small RCS combined with speed to reduce the range of an adversary's air defences to a point where they effectively become useless, his definition is equally applicable to ECMs which performed a similar function.[47] As the function of the Mandrel ECM was to shorten FuMG-80 detection range to around 34.4nm (63.7km), this was a clear example of the Stealth/Surprise method of SEAD application.

While the FuMG-80 radars were to be jammed using Mandrel, as Addison observed in an April 1944 letter to Dalton-Morris, the threat from the FuMG-62D, although diminished, had not entirely disappeared.[48] These radars were still employed for the GCI of fighters towards Bomber Command aircraft which had become separated from the Main Force, or in areas where Window was not sufficiently dense to disrupt the operation of these radars.[49] Window also presented its own challenges as an ECM. In order to provide adequate protection to the Main Force, a significant quantity of Window had to be carried, and then dispersed during the operation. As noted in Saundby's letter to Harris on 13 November 1943 discussing the

[45] 'Minutes of the Third Meeting on Radio Countermeasures Policy and Progress, Held at Bomber Command on 18 March 1944', AVIA 7/2303.
[46] '100 Group Summary of Events December 1943-April 1944', AIR 20/9037.
[47] Dougherty, *Defense Suppression,* p.25.
[48] 'Letter from Air Cdre. Addision, AOC-in-C 100 Group to Air Cdre. L. Dalton-Morris, Command Signals Officer', AIR 14/2657.
[49] 'Letter from Air Cdre Addison, AOC-in-C 100 Group to AVM Walmley, Bomber Command SASO, 2 March 1944', AIR 14/2657.

development of ECMs, it would remain necessary for Window to be carried and dispersed by as many aircraft as possible in the Main Force to ensure adequate protection, despite the activation of 100 Group for specialist EW tasks. The Window ECM would only be effective in protecting a large and densely-packed formation of aircraft, could not protect a formation of aircraft less than 100 aircraft in size, and was incapable of protecting the spearhead of the Main Force and any aircraft which became detached from the Main Force. Finally, it had to be manually dispersed by the aircrew which imposed an additional work burden during the most dangerous part of the mission when the bomber was over enemy territory.[50]

Therefore, Bomber Command would still press ahead with the development of additional ECMs to counter the FuMG-62D radar.[51] A remedy was found in the form of the Carpet ECM which was designed to jam FuMG-62D radars transmitting in the 530MHz to 580MHz waveband.[52] Entering service in April 1944, Carpet was to be deployed at the Localised level as it was designed to protect individual aircraft, and to supplement the protection of the Main Force for the duration of their mission. This protection, like Mandrel, was afforded by applying Stealth/Surprise given that it reduced the useful range of FuMG-62D radars.[53] This ECM was installed on the Fortress-BII/III aircraft of 214 Squadron. Harris stated that the ECM initially gave good results in reducing the loss rates for aircraft outfitted with the ECM relative to those aircraft not in possession of it. However, as is often the case in electronic warfare, the benefits afforded by a particular ECM are temporary, and the *Luftwaffe* adapted its FuMG-62D radars to transmit across a wider frequency band to outflank the frequencies which Carpet was capable of jamming. Harris observed that Carpet 'undoubtedly caused the

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[50] 'Letter from AVM Saundby to ACM Harris 'Development of Radio Countermeasure Equipment', 13 November 1943', AIR 20/4715.
[51] *Ibid.*
[52] Grehan, Mace, *Bomber Harris*, p.281.
[53] AIR 20/8070.

Germans some inconvenience and made them expend some effort in finding the answer to it, but on the whole it must rank among the least successful of the countermeasures attempted by the Command'.[54]

Command losses began to reduce in March 1944, down to three percent of sorties despatched, and would continue to lessen throughout the period under examination, resulting in losses of 2.1 percent for May 1944. As Harris observed by April 'it was clear that we had at last got the measure of the German defences and had the enemy at our mercy'.[55] Yet in early April, *Luftwaffe* fighter tactics changed once more. The force consolidated extensive fighter coverage over southwest German so as to engage RAF bombers during their ingress and egress to and from their targets.[56] This was facilitated by a network of radio beacons around which formations of fighters could be assembled. The use of these high powered radio beacons became apparent to the RAF in April 1944, and measures were taken to employ jamming against them in the form of the Fidget ground-based ECM. Fidget was essentially a 'Meacon', a portmanteau of the words 'masking beacon'. The process of 'Meaconing' was designed to give fighters a false indication of their bearing from a particular beacon by using MF transmissions. Fidget would transmit random Morse code superimposed on the beacon it was intending to jam.[57] While this ECM was deployed for Localised SEAD its use of false bearing indications show that the ECM used the Manoeuvrist method of application.[58]

As the period under review in this chapter drew to a close, by late-May ELINT efforts had determined that the use of beacons positioned at Leeuwarden, in the northern Netherlands,

[54] Grehan, Mace, *Bomber Harris,* p.281.
[55] Harris, *Bomber Offensive*, p.156.
[56] AIR 41/56, pp.36-37.
[57] AIR 14/2343, p.40.
[58] Bellamy, 'Manoeuvre Warfare', p.541.

and to the south of the Zuider Zee, in the western Netherlands, and a third beacon at Aachen in western Germany close to the Belgian border, effectively provided a western 'wall' of fighter coverage through which Bomber Command would have to fly if taking the most direct route from the UK to its Ruhr Valley targets.[59] Any attempt to outflank these defences by flying across northern France from the UK towards the Ruhr Valley would force the Command's aircraft to fly in proximity to these fighter beacons and airbases established in northern France and Belgium. While the first half of 1944 had seen strenuous efforts by the Command to reduce the potency of the *Luftwaffe* IADS in the face of rising losses through the adoption of new Main Force tactics and also the roll out of new ECMs and ELINT gathering techniques, it was clear that the *Luftwaffe* was not yet defeated and continued to pose a threat to the success of the strategic air campaign. Pointblank, and subsequent directives, had emphasised the destruction of *Luftwaffe* air power as a prerequisite for the successful outcome of Operation Overlord, yet on the eve of this effort, which will be discussed in the following chapter, the *Luftwaffe* remained a force to be reckoned with capable of inflicting at times significant losses on Bomber Command.

Conclusions

The existing literature examining Bomber Command's EW efforts between November 1943 and May 1944 focused on the enlargement of 100 Group's order of battle; conveyed accounts of its individual personnel; discussed the activation of dedicated ELINT and jamming units within the Group, its air-to-air operations and the adoption of dedicated EW aircraft. It largely demurred from a discussion of the drafting of Bomber Command's EW policies and how they

[59] 'Report on Casualties in Night Operations – 21/22 May 1944, Duisberg, Hannover, Minelaying', AIR 14/3247, No. 100 Group: interim reports on cost of night operations, Belgium, France and Germany, February 1944-May 1944.

were enacted via SEAD. As with the discussion regarding the activation of 100 Group, during the timeframe under examination, authors largely confined themselves to studying the tactical aspects of Bomber Command's EW activities as opposed to its decision-making regarding EW policy.

Shortly after 100 Group's activation in November 1943, Saundby reflected on the importance that ECMs and EW in general had played to date in reducing the effectiveness of the *Luftwaffe* IADS. In this regard he betrayed his Campaign level SEAD intentions as regards the role that the Group should play in continuing to keep the Command's losses to a minimum as a means of ensuring the strategic air campaign's success. His Campaign level SEAD thinking was echoed by Addison who, in his April 1944 letter to Dalton-Morris, clearly stated his belief that the Group as a whole, both in kinetic and electronic terms, was to be used to attrit the *Luftwaffe*. At the same time, Dalton-Morris' belief that the initiative had, and always would remain with the *Luftwaffe* due to the force's tactical ingenuity, betrayed a resignation that the Command would be condemned at the same time to enact reactive EW policies. Nonetheless, as this chapter has demonstrated, the decision to jam comparatively low waveband VHF communications with the ABC ECM was an example of a proactive EW policy intended to warn the *Luftwaffe* against the further use of such frequencies for radio communications.

The first six months of the Group's operations saw several ECMs entering service such as the Dartboard countermeasure employed against MF radio transmission used to relay instructions to fighters. This ECM was deployed at the Localised level and applied Mass, as did the Rayon ECM intended to jam *Luftwaffe* Ottokar transmissions, and Drumstick directed against

Luftwaffe W/T and R/T traffic. Nevertheless, while these ECMs employed the Mass approach, the advent of the ABC, Mandrel and Carpet ECMs in service with 214 Squadron was an example of Localised SEAD being employed using the Mass and Stealth/Surprise approaches respectively, while the Fidget ECM employed a Manoeuvrist approach. These realisation and deployment of these ECMs were examples of reactive EW policies in that they were devised as an answer to a specific *Luftwaffe* threat. That said, 100 Group's ELINT gathering efforts exemplified Campaign and Localised SEAD thinking, intended as they were to contribute to the reductions of Main Force losses on any given night of operations, while contributing to the long-term reduction of the potency of the *Luftwaffe* IADS. During the first six months of 100 Group's operations, the Command had to rely on existing airborne ECMs, and on existing and newly-deployed ground ECMs to help protect its aircraft. This was because much of the first six months of 100 Group's existence was spent reaching a point where it could employ airborne ECMs *en masse* against the *Luftwaffe* IADS, with the establishment of 214 Squadron being an important first step. As Addison observed:

> (T)he birth pangs during (100 Group's) delivery have been particularly acute. Nevertheless the infant has prospered and has certainly grown apace in weight and strength although at times its demands may have seemed unduly vociferous. Such a trait, however, is that of a healthy baby.[60]

That 'healthy baby' would now endure a baptism of fire as the Group was called upon to direct its airborne and ground-based ECMs in their entirety against the *Luftwaffe* IADS as a vital part of the effort to assist the preparation and performance of Operation Overlord.

[60] AIR 20/9037.

CHAPTER SIX

BOMBER COMMAND'S ELECTRONIC WARFARE POLICY AND SUPPRESSION OF ENEMY AIR DEFENCE POSTURE BEFORE AND DURING OPERATION OVERLORD

Introduction

While Chapter Five examined the first six months of 100 Group's operations, and Bomber Command's EW policy and SEAD posture writ large between November 1943 and May 1944, this chapter will commence by detailing the overall objectives of the Operation Overlord air plan; principally to achieve air superiority via the destruction of the *Luftwaffe* fighter force, and the German aviation industry; and to isolate the Normandy theatre of operations from Germany via the destruction of rail targets. The chapter will continue that for Bomber Command this would mean the continued attack of industrial targets in Germany, along with the attack of the German aviation industry and, later once the invasion had occurred, the direct support of the Allied ground offensive to break out of the Normandy theatre of operations. 100 Group was to play a key part in the effort to establish air superiority over the Normandy theatre, as stipulated in its original requirements alongside its continued support of the strategic air campaign. The efforts of the Group would include the application of its dedicated airborne EW force, which had been increasing in size and scope since 214 Squadron commenced operations in April 1944. The chapter will note that, alongside the attack of rail targets, air operations in Normandy witnessed the kinetic attack of radar installations. Beyond these kinetic attacks, the chapter will add that the Command mounted a significant effort against *Luftwaffe* radars and coastal radars with the intention of deceiving the German political and military leadership as to where the invasion would land. This included the use of the Mandrel ECM to mask the airborne element of the operation from detection, while the ABC and Ground Cigar ECMs were deployed to jam *Luftwaffe* radio communications.

The Overlord Air Plan

Overall, the air plan for Overlord was to have two phases; the first was to degrade *Luftwaffe* fighter strength to prevent it from interfering with Allied air operations in support of the invasion, and to help the Allies win air superiority over Normandy, north-western France, where the amphibious and airborne landings would occur, and over the land and sea approaches to these locations. The first phase of the Overlord air plan was to be pursued by the United States Strategic Air Forces [USSTAF], which comprised the USAAF strategic bomber force in Europe, and Bomber Command to perform attacks against the *Luftwaffe's* fighter force and Germany's aviation industry. The second phase would see the attack of rail links between western Germany and northern France to hamper the ability of the enemy to reinforce the Normandy Theatre; this phase being known as the Transportation Plan. Furthermore on 6 June, when the invasion would commence, both the USSTAF and Bomber Command would widen their attacks to include additional targets such as enemy airfields in the *locale* of the invasion area, radar stations and coastal batteries. Bomber Command was also tasked with mine-laying operations to help prevent the *Kriegsmarine* (German Navy) from interfering with the naval element of Overlord.[1]

The air plan for Overlord was detailed in two directives issued on 4 March and 17 April 1944. The 4 March directive from AVM William Coryton, the assistant chief of the air staff for operations to Harris detailed the two objectives of the strategic air campaign on the eve of Overlord. The directive was to 'provide targets, the attack of which is most likely to be of assistance to 'Pointblank' and 'Overlord''. The directive emphasised the importance of attacking Friedrichshafen in southern Germany to destroy facilities in this city where automotive components, notably armoured vehicle engines and transmissions were produced. Interestingly, the directive drew attention to the city's 'importance in the production of radar equipment'. Friedrichshafen had already been attacked on the night of 20/21 June 1943 in an effort to hit a factory in the city which was thought to be producing antennae for FuMG-62D radars. While the kinetic attack of such targets is not the focus of this thesis, the efforts of the Command to perform such attacks against the IADS, and its supporting elements, is worthy of future study. The directive concluded that, regarding Friedrichshafen, the city should be attacked by the Command during a moonlit period in March. With an eye towards the Transportation Plan, the 4 March directive stressed the need for the Command to attack railway targets, particularly on nights when the engagement of Pointblank targets was not practical. Several targets were detailed by the directive, notably the railway marshalling yards at Trappes (northern, central France), Aulnoye on the Franco-Belgian border, Le Mans (north-western France), Amiens (northern France), Courtrai (close to the Franco-Belgian border) and Laon (northern France), with other railway targets to be detailed once the Overlord air plan

[1] AIR 41/56, p.27.

was finalised. Other targets stipulated in the directive included the airfield at Montdidier-Fignières, reportedly a base used by the *Luftwaffe's* equivalent of Bomber Command's Pathfinder force.[2] Other *Luftwaffe* targets included the ammunition dump at Maintenon, southwest of Paris.

The 4 March directive was superseded by a further directive issued on 17 April. Recognising that, despite the emphasis on invasion targets enshrined in the 4 March directive, the strategic air campaign was to continue its attacks against 'the German military, industrial and economic system' alongside 'vital elements of lines of communication' during the preparations for invasion. The directive continued that the priority would remain the destruction of the *Luftwaffe*, as emphasised in the Pointblank directive. The destruction of the *Luftwaffe* was highlighted by the directive as the *sine qua non* for the success of both the strategic air campaign and the invasion which depended on 'the overall reduction of the enemy's air combat strength and particularly his air fighter strength'. This would be done to 'secure and maintain air superiority'. It also stressed the importance of assisting the land forces supporting Overlord, stressing that 'all possible support must, therefore, be afforded to the Allied Armies by our Air Forces to assist them in establishing themselves in the lodgement area'. This support, the directive added, would initially be given by 'interfering with rail communications, particularly as affecting the enemy movements and concentrations in the 'Overlord' area'. Ultimately, the twin tasks of the USSTAF and Bomber Command would be to attrit the *Luftwaffe* to the fullest extent possible, and to destroy rail communications serving the Normandy theatre. The directive added that Bomber Command was to 'continue to be employed in accordance with their main aim of disorganising German

[2] '4 March 1944. Air Vice Marshal W.A. Coryton (Assistant Chief of the Air Staff (Operations)) to Air Chief Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.165-167.

industry'. Furthermore, the Command was to assist the USSTAF in destroying *Luftwaffe* targets, in terms of its fighter force and the German aviation industry, and to destroy and disrupt rail communications.[3] Other tasks required of both the USSTAF and Bomber Command as stipulated by the directive included potential emergency attacks in support of ongoing Allied operations in the Mediterranean and Balkans theatres, German naval targets, so-called Crossbow targets associated with Germany's surface-to-surface missile programme, and the support of the UK's Special Operations Executive which was performing clandestine missions across occupied Europe. Interestingly, in the aftermath of the invasion, Bomber Command would be called upon to perform direct attacks against the German Army in support of the ground offensive to break out of the Normandy theatre following the 6 June landings. This would include attacks on German Army troop concentrations on the night of 14/15 June south of Bayeux to the west of the invasion beaches; on 30 June in the vicinity of Villers Bocage (also in western Normandy); on 7 July in support of ground operations against Caen (western Normandy) and on 18 July on targets south of Caen.[4] The two directives of March and April, Overy posited, heralded a change in the direction of the strategic air campaign. He argued that previously the strategic air campaign had been used to indirectly assist the invasion by attacking German industry and *Luftwaffe* air power, but that now it was to directly assist the invasion, notably through the Transportation Plan.[5] However, as Harris noted this direct assistance was not performed at the expense of other Command operations, as it continued its policy of hitting cities with industrial targets in Germany, although 'only in the most favourable of conditions', adding that: 'Few risks were taken.'[6]

[3] '17 April 1944. Directive by the Supreme Commander to USSTAF and Bomber Command for support of 'Overlord' during the preparatory period', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.167-169.
[4] Grehan, Mace, *Bomber Harris*, p.73.
[5] Overy, *The Air War,* pp.75-76.
[6] Grehan, Mace, *Bomber Harris*, p.233.

The requirements of Bomber Command to assist the establishment of air superiority in support of both the strategic air campaign and the success of Overlord translated into an important role for 100 Group. One of the Group's missions was to provide support for combined operations launched from the United Kingdom, in addition to its overall role of giving 'direct support to night bombing or other operations by attacking enemy night fighters in the air, or ground installations' and employing 'airborne and ground (ECM) apparatus to deceive or jam enemy radio navigation aids, enemy radar systems and certain enemy wireless signals'.[7] Just over six months from its creation in November 1943, the Group would be tasked with performing these two parts of its mandate simultaneously to assist Overlord and also the ongoing strategic air campaign. Harris observed that the Group adopted a Campaign SEAD mindset as regards its SEAD efforts in support of the invasion, and he wrote that 'in the three months before (6 June) … much of the RCM development in Bomber Command was concentrated on the part which RCM was planned to play in support of the landings'.[8] As noted in the previous chapter Addison, the Group's AOC, had stated in a 14 April 1944 letter to Dalton-Morris that the Group had a key role in 'wearing down the Huns' over the long term.[9] This intention clearly met the definition of employing SEAD at the Campaign level.[10] What is interesting about Addison's statement is that he made this on the eve of Overlord, when his Group, and Bomber Command's EW efforts in general, would be expected to play an important role, particularly in support of the airborne dimension of the operation. Overlord

[7] 'Role and Function of No. 100 (SD) Group, AVM Walmeley, SASO, Bomber Command 21 March 1944', AIR 2/7309.
[8] Grehan, Mace, *Bomber Harris*, p.281.
[9] 'Letter from Addison to Air Commodore L. Dalton-Morris, Command Signals Officer, HQ Bomber Command, 17 April 1944', AIR 14/2657.
[10] Baltrusaitis, *Quest for The High Ground*, p.3.

was the only such mission which 100 Group supported to this end, hence why it is of interest to this chapter, and to this thesis in general.

While during the period between November 1943 and May 1944 examined in the previous chapter 100 Group possessed a solitary dedicated unit, in the form of 214 Squadron, capable of performing airborne EW, its complement in this regard began to increase in the spring of 1944. The Group received two new units: The first took the form of the USAAF's 803 Squadron which had joined 100 Group on 28 March 1944, but which remained under the operational control of Bomber Command.[11] 803 Squadron's B-17F/G converted heavy bombers were joined by the Shorts Stirling-BIII aircraft of 199 Squadron. The Stirling-BIII joined 199 Squadron from April 1944, outfitted with the Mandrel ECM.[12] The Mandrel sets would perform barrage jamming across the FuMG-80 entire 70MHz to 150MHz waveband, while the aircraft's IFF Mk.III IFF transponders would be used for spot jamming, where specific FuMG-80 frequencies were jammed across a range of 150MHz to 200MHz. The Stirling-BIIIs of 199 Squadron were joined in Mandrel jamming by 803 squadron which also carried this ECM alongside the Jostle-IV ECM (*see below*) onboard their B-17F/Gs.[13]

Figure XI - 100 Group Order of Battle: November 1943 - June 1944

Squadron	Base	Aircraft	Role
192	RAF Foulsham	Mosquito-BIV/XVI Wellington-BIII Halifax-V Mosquito-II	ELINT gathering
141	RAF West	Beaufighter-VI	Fighter

[11] 'Part 1 Story of 100 Group Night Fighters: The Enemy Night Defence System when 100 Group was formed', AIR 14/2911.
[12] '100 Group Summary of Events December 1943-April 1944', AIR 20/9037.
[13] Streetly, *Confound and Destroy*, p.207.

	Raynham		
		Mosquito-II/VI/XXX	
239	RAF West Raynham	Mosquito-II/VI/XXX	Fighter
515	RAF Little Snoring	Mosquito-II/VI	Fighter
169	RAF Little Snoring	Mosquito-II/VI/XIX	Fighter
214	RAF Sculthorpe/RAF Little Oulton	Fortress-BII/III	Electronic Warfare
199	RAF North Creake	Stirling-BIII	Electronic Warfare
803	RAF Cheddington	B-17F/G	Electronic Warfare
157	RAF Swannington	Mosquito-XIX/XXX	Fighter
85	RAF Swannington	Mosquito-XII/XVII	Fighter

Source - Bowman, T. Cushing, *Confounding the Reich: The RAF's Secret War of Electronic Countermeasures in WWII* (Barnsley: Pen and Sword Aviation, 2004), p.234 and M. Streetly, *Confound and Destroy: 100 Group and the Bomber Support Campaign* (London: MacDonald and Jane's, 1978), pp.235-255.

While the Group's order of battle was being enhanced with these two new squadrons, the Group's original 'heavy' unit in the form of 214 Squadron began to have its Fortress-BII/III aircraft, already outfitted with ABC retrofitted with the Jostle-IV ECM. The squadron's aircraft began to be retrofitted with the ABC from May 1944 but it would not be until June 1944 that these aircraft would commence sorties thus equipped. The choice of 214 and 803 Squadrons for the Jostle-IV ECM was because the aircraft was said to be the only platform physically capable of accommodating this ECM.[14] The ECM was designed to jam *Luftwaffe* High Frequency [HF] and Very High Frequency [VHF] radio communications, and could also be employed against radio navigation transmissions. Jostle-IV had a jamming range of 34 nautical miles/nm (63 kilometres/km) and was intended to accompany the Main Force with one Fortress-BII/III or B-17F/G aircraft positioned every 8.6nm (15.9km) to 10.3nm (19.1km)

[14] *Ibid.*, p.159.

along the bomber stream.[15] Its provision of jamming to support the Main Force for the duration of the latter's operations accords with Baltrusaitis' definition of Localised SEAD which is performed with 'specified time and space limitations (and) supports specific operations or missions'.[16] Additionally, Jostle-IV would apply Mass.[17] The ECM's introduction was also the result of a reactive EW policy as it was intended to neutralise the threat posed by *Luftwaffe* HF and VHF radio communications.

March 1944: The Attacks Commence

The Transportation Plan commenced in early March and would have strategic and tactical elements: The strategic element would see Bomber Command hitting major rail targets such as locomotive depots; and maintenance, repair and overhaul facilities in northern France and western Germany. Its aim was not to bring rail traffic to a standstill, which the official history stated would have been impossible due to the number of targets which Bomber Command would have to strike in the available time before D-Day, but to force more rail traffic to use an increasingly finite number of junctions and lines, causing congestion, and to force the increasing use of road transportation. The tactical phase of the Transportation Plan would then be enacted to attack chokepoints such as road and rail bridges, and junctions, to restrict the enemy's ability to reinforce the Normandy theatre.[18]

On 2 March 1944, the AOC-in-C of the Allied Expeditionary Air Force [AEAF], which included the RAF and USAAF elements supporting Overlord, ACM Trafford Leigh-Mallory asked the Air Ministry for permission to commence day and night attacks against 75 rail

[15] AIR 20/8070.
[16] Baltrusaitis, *Quest for The High Ground,* p.3.
[17] Dougherty, *Defense Suppression,* pp.26-27.
[18] AIR 41/56, pp.37-38.

centres in Belgium and France. These began on the night of 6/7 March with a Bomber Command attack against the marshalling yard at Trappes. Attacks against rail targets continued into April, with Bomber Command commencing its mine-laying operations earlier that month. By May, the USAAF had begun to attack rail targets, and between the start of the month, and 6 June, Bomber Command hit 32 rail targets, some of which were repeat attacks. Furthermore, military targets were attacked by Bomber Command, notably the ammunition dumps at Maintenon, Aubigne-Racan, Louailles, Salbris and Bruz in north-western and central France.[19]

In tandem with the Transportation Plan, the RAF would commence attacks against the *Luftwaffe* IADS. The coast of Western Europe from Norway southwards to the Franco-Spanish border was protected by a radar chain established by the *Luftwaffe*. Radar coverage was particularly dense between Ostend on the Belgian coast, south-west towards Cherbourg on the French Channel coast, with an average of three radars stationed every ten miles (sixteen kilometres) along the coast within this area. These radars posed a twin threat to the air and surface forces supporting Overlord as they would be able to detect Allied aircraft and ships. The Allied High Command directing Overlord intended for these radars to be struck using both kinetic and electronic means. To preserve security and to deceive the enemy as to where the invasion would fall, two radars outside the invasion area were hit, for every one radar station within it.[20]

[19] *Ibid.*, pp.38-49.
[20] *Ibid.,* pp.44-45.

Much of the kinetic effort against the radar stations was made by the fighter-bombers of the AEAF which flew a total of 1668 sorties against radar installations prior to 6 June.[21] Kinetic attack was an important aspect of the RAF's OCA efforts against the IADS. As a target, radar stations were typically small in size, compared to an airfield, or an aircraft factory. As a consequence of this, it was not considered practical to attack them using Bomber Command's aircraft. Instead, fighter-bombers from the AEAF were tasked to hit such targets. Typically, a strike package of aircraft would include one fighter-bomber equipped with a Radar Warning Receiver [RWR] tuned to the targeted radar's frequency which would assist the strike package's efforts to home in on the RF transmissions, and hence locate the radar. The radar could then be attacked using conventional ordnance, cannon and machine gun fire. The RAF employed a device known as Abdullah to locate hostile radars, with six Hawker Typhoon fighter-bombers thus equipped to form the 1320 Special Duties Flight.[22]

In this respect, the RAF was ahead of its time, as it had unwittingly pioneered a concept of operations by which a combat aircraft would carry a RWR to allow an accompanying group of aircraft to locate and attack a ground-based air surveillance or FC/GCI radar. This concept of operations would later be exploited more fully by the USAF and USN during the Vietnam War as part of its Iron Hand and Wild Weasel efforts (*more details of which can be found in Chapter One*). There are tantalisingly few references to the success or otherwise of the Abdullah operations in the official records of the RAF. Similarly, there are scant mentions of it in the published literature surrounding Bomber Command's EW efforts. The existing historiography examining the RAF in the Second World War would certainly benefit from a more detailed analysis of the Abdullah initiative. Although the USAF and USN are credited

[21] *Ibid.*
[22] AIR 41, p.229.

with realising the Iron Hand/Wild Weasel concept, the groundwork for this may have been unwittingly laid by the RAF in Western Europe twenty years previously.

Furthermore, the attack of ground-based radar installations by fighter-bombers during the preparatory phase of Overlord may provide an explanation as to why radars were not attacked in this fashion as part of the SEAD dimension of the wider strategic air campaign. Targets such as radar installations, and GCI centres, from where fighter operations were directed, but which would rarely constitute more than a handful of buildings, were relatively small targets. One the one hand, this would make them impractical to attack from high altitudes by the strategic bombers of the RAF and the USAAF. Aircraft such as the Typhoon-1B had a range of 443nm (821km) which was eclipsed by the 2200nm (4073km) range of heavy bombers such as the Lancaster-BI, meaning that the Typhoon-1B might not have possessed the necessary range to hit such targets in Germany, although these aircraft were used to attack some IADS targets such as FuMG-62D radar emplacements during the prelude to Overlord. Moreover, once the Allies had gained a foothold in France, tactical aircraft such as the Typhoon-1B were primarily tasked with close air support and battlefield interdiction tasks in support of the Allied advance and were thus not available to assist in kinetic attacks against IADS targets. Nonetheless Bomber Command did possess longer-range fighter-bombers such as the De Havilland Mosquito-BXVI which had a range of 1300nm (2400km), which presumably would have been sufficient to hit such targets in support of the strategic air campaign. There are no references in the official records examined as part of this theses to the Mosquito being proposed, or indeed executing, such a role and it is possible that this aircraft was never used in such a fashion because of Bomber Command lacking confidence in its abilities to this end, or believing that it was better placed to perform Intruder attacks against *Luftwaffe* fighter airfields.

Alongside the attack of radar stations, the RAF struck airfields in the *locale* of the invasion area to assist the achievement of air superiority. This included the airfield at Montdidier in northern France which was struck on the night of 3/4 May by aircraft from Bomber Command's 8 Group, with additional attacks performed on 7/8 May by 1, 3 and 8 Groups against the airfields at Rennes, western France; Tours, central France and Nantes on the Atlantic coast. Throughout the rest of the month, further Bomber Command attacks were performed against airfields at Courtrai (on the Franco-Belgian border), Caen and Orly (southern Paris). Seven days after Bomber Command commenced its attacks on *Luftwaffe* airfields in the *locale* of the invasion area, the RAF began attacks against the radar stations discussed above. On 10 May, kinetic attacks commenced against ground-based air surveillance radars, with attacks against FC/GCI radars used for fighter control, and for the fire control of coastal batteries, beginning on 17 May.[23]

Prior to the attacks commencing against FC/GCI radars used to provide fire control for coastal batteries, attacks had begun against the coastal batteries themselves on the night of 7/8 May when Bomber Command hit the coastal battery at Saint-Valery-en-Caux on the Channel coast, striking the batteries at Cap Gris Ney, Berneval and Morsaline, also on the Channel coast, on the night of 8/9 May, with 30 such attacks made against coastal batteries by the end of the month.[24] Harris noted that coastal defences stretching from Brest, the most westerly tip of France to the Scheldt estuary in the Netherlands were hit with the intention of maintaining

[23] AIR 41/56, pp.44-45.
[24] *Ibid.*, p.48.

uncertainty within the German armed forces and political leadership as to where the invasion would occur, with a rule that for every one coastal defence target attacked in the invasion area, two would be bombed elsewhere on the coast.[25]

Kinetic attacks were performed against other IADS targets, notably a radio communications installation close to the French Channel coast which was badly damaged on the night of 31 May/1 June by Bomber Command aircraft from 6 and 8 Groups. The same night witnessed an attack on the radio installation at Au Fevre, to the west of the Normandy landing beaches, with similar installations at Berneval and Ferme d'Urville near Cherbourg being struck.[26] Nevertheless as this thesis focuses on the EW efforts of Bomber Command against the *Luftwaffe* IADS, kinetic attacks against the IADS prior to, during and after D-Day as part of the Overlord effort will receive no further examination.

On 3 June the strategic element of the Transportation Plan finally came to a close with a total of 37 rail centres in northern France and Western Germany having been attacked by Bomber Command. Including rail targets attacked by the USSTAF, a total of 51 such targets had either been destroyed outright or seriously damaged. With the strategic element of the Transportation Plan complete, it would now enter the tactical phase, during which attacks against road and rail chokepoints would commence to restrict the enemy's ability to reinforce the Normandy theatre. This phase would commence on D-Day itself and continue until 18 August.[27]

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[25] Grehan, Mace, *Bomber Harris*, p.69.
[26] AIR 41/56, p.45.
[27] *Ibid.*, p.42, p.83.

Beyond radar attacks, Bomber Command performed Intruder operations against *Luftwaffe* airfields and fighters arriving at, and departing from, these airfields. 100 Group's 85 and 157 Squadrons commenced these attacks on the night of 5/6 June, and continued until 21 July, when these units were withdrawn and re-tasked to attack V-1 'Doodlebug' surface-to-surface missiles which had commenced strikes against London on 13 June 1944, as part of the Crossbow effort[28]

For One Day Only: EW in Support of Overlord

As noted above, the Command's efforts directed against the IADS included electronic as well as kinetic aspects. The electronic aspects were directed against the IADS' radar and radio communications.[29] Of interest to this chapter was the fact that the efforts of Bomber Command to neutralise these electronic elements represented the first massed deployment of airborne ECMs by 100 Group. As detailed in the previous chapter, the first six months of the Group's operations had seen it largely building up its airborne electronic attack capabilities.[30] It would not be until the preparatory stage of Overlord that 100 Group would be able to bring its airborne EW capabilities to bear against the IADS.[31] To this end, 100 Group's EW efforts would comprise several distinct strands:

(a) To prevent the enemy obtaining early warning of, and accurate plots on, approaching surface forces.
(b) To prevent coastal batteries from using radar-controlled gunfire against surface forces.
(c) To support airborne operations by –

[28] AIR 41, p.177.
[29] *Ibid.*, p.221.
[30] AIR 14/2343.
[31] 'Radio Counter-Measure Organisation, Role and Functions of No.100 (SD) Group, AVM Walmeley, 21 March 1944', AIR 2/7309.

(i) Reducing and confusing the enemy's early warning system, thus delaying both the arrival of fighters amongst the troop carriers and the alerting of the threatened dropping zones.
(ii) Interfering with enemy fighter control R/T, thus affecting both the movement of night fighters into the area of operations and the vectoring of intercepting fighters.
(iii) Producing diversionary threats and thereby dividing the enemy's available fighter cover.

(d) To delay the movement of enemy reserve ground forces by producing threats of apparent assaults, both airborne and seaborne.[32]

The three elements which comprise point 'c' discussed above are of most interest to this chapter. Much of the application of airborne ECMs would occur immediately prior to the commencement of the landings on the morning of 6 June and on the night of the 5/6 June respectively. In the 24 hours prior to the commencement of the amphibious and airborne operations, airborne ECMs would be employed to prevent the detection of shipping and aircraft by radar. As well as jamming radar, the RAF's EW effort was intended to deceive the enemy that the invasion would make landfall between Cap d'Antifer in Normandy and Boulogne-sur-Mer on the northern French coast, to the east of the actual landing area located chiefly in the Calvados *department* of Normandy. This deception was to be realised by two separate combined operations known as Taxable and Glimmer, at the same time the airborne element of Overlord would be protected from radar detection by the Mandrel ECM while the ABC and Ground Cigar ECMs were to be employed to jam enemy fighter radio.[33]

The Mandrel element of the operation was intended to protect the airborne forces supporting Overlord against detection by FuMG-80 radars. Alongside the FuMG-80 radars which the *Luftwaffe* had deployed, the Allies had to face the FuMo-51 and Siemens FuMG-402 *Wassermann* ground-based air surveillance radars which had been deployed to detect hostile

[32] AIR 41, p.228.
[33] *Ibid.*, p.233.

aircraft. The FuMG-402 radars could be destroyed by kinetic attack, as could the FuMo-51 radars. However, due to their relatively small physical size and lattice antenna construction which made them difficult to hit with air-to-ground fire, FuMG-80 radars would need to be attacked with ECMs, to which they were judged to be particularly susceptible. In tandem with the FuMG-80 radars, the Allies faced the threat posed by the FuMG-62D and FuMG-65 FC/GCI radars. The FuMG-65 radars were attacked prior to 6 June using rocket and cannon fire, while the FuMG-62D radars were largely left alone due to their short range of about 16nm (30km) which was not thought to be sufficient to have an appreciably dangerous effect on the success of the amphibious and airborne elements of Overlord. Nevertheless those FuMG-62D radars near the coast were targeted by the employment of the Window ECM as part of Operation Taxable.[34] Interestingly, the use of Window in this regard was not to protect Main Force aircraft as it had been in the past, but rather to produce spurious echoes on German coastal radar screens with the intention of creating the impression of a large fleet of ships heading towards the Cap d'Antifer to the east of the invasion beaches, with the Command's 617 Squadron dispersing Window in such a fashion as to give the illusion of a convoy of ships moving towards the French coast at seven knots (12.9 kilometres per hour). A similar effort in the form of Operation Glimmer was performed by 218 Squadron also dispersing Window with the objective of convincing German coastal radar that a large naval fleet was approaching the Pas de Calais.[35] As these two operations were not concerned with suppressing the IADS, they will receive no further examination.

The Mandrel Screen would form a major part of Bomber Command's EW effort against the IADS. Its *modus operandi* required Stirling-BIII aircraft from 199 Squadron and B-17F/Gs

[34] *Ibid.*, pp.230-233.
[35] Grehan, Mace, *Bomber Harris*, p.294.

from 803 Squadron.[36] The Screen would be implemented to 'prevent coastal radar from warning the enemy of the approach of airborne forces.' The Mandrel Screen would involve the participating aircraft flying across two fronts above the channel, each separated by 43nm (23.2km) at a distance of 43nm from the French channel coast so as to provide a curtain of jamming. Aircraft would be distributed equally between the two fronts, and Mandrel jamming would begin at 0000 hours on 5 June ceasing at 0530 hours on 6 June.[37] The jamming would be performed using pairs of Stirling-BIIIs equipped with Mandrel spaced with 24nm (12.9km) between them jamming the FuMG-80's entire frequency band of 70MHz to 200MHz. Between each pair of Stirling-BIIIs, B-17F/Gs would be positioned to cover any narrowband radar frequencies of 120MHz to 140MHz which could not be jammed by the Stirling-BIII's Mandrel ECMs.[38] These Stirling-BIII and B-17F/G formations were located at eight fixed points above the Channel around which they would orbit.[39] The reason for the use of several aircraft to populate the Mandrel Screen was because of the requirements of the ECM regarding its power consumption, plus the propagation characteristics of the jamming signals emitted by the countermeasure. This meant that a single aircraft equipped with Mandrel would not be sufficient to jam the entire required frequency range, at the required distance from the radar. By using several aircraft, the entire range of frequencies could be jammed by the Mandrel ECMs.[40] The function of the Mandrel Screen was to greatly reduce the detection range for the FuMG-80 radars from around 154nm (83.1km) to 34.4nm (18.5km).[41] The Mandrel operation was broadly successful in shielding the airborne element of the invasion

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[36] AIR 41/56, p.85.
[37] 'AEHF RCM Requirements, Report on Meeting held at Bomber Command on the 11th March, 1044, Air Commodore Constantine in the Chair', AIR 20/4715.
[38] AIR 41, p.198.
[39] 'No.100 Group Fortnightly Progress Report No.9 (For Fortnight Ending 7 June, 1944)', AIR 14/2348.
[40] AIR 41, p.236.
[41] AIR 20/8070, p.5.

from detection by ground-based air surveillance radar, with 100 Group's fortnightly progress report of 21 June reflecting that:

> It is, as yet, too early to assess the results obtained from the Mandrel Screen which these aircraft put up, but from evidence so far available it would appear that the operation achieved a satisfactory measure of success during the invasion operations.[42]

The Mandrel Screen was intended to jam the *Luftwaffe's* ground-based air surveillance radars in such a fashion as to prevent them from 'seeing' the incoming aircraft supporting the airborne operation and as such accorded with Baltrusaitis' definition of Localised SEAD.[43] In this instance, the specific mission was the airborne element of Overlord, the specific area was the airspace through which the transport aircraft and gliders would have to fly to reach their objectives and the specific timeframe was from midnight 5 June until the early morning of 6 June. The employment of the Mandrel Screen utilised Dougherty's Mass SEAD approach as it saturated the *Luftwaffe* IADS covering the invasion area with a large number of dedicated aircraft using a similarly large number of dedicated countermeasures. Nevertheless, the use of the Mandrel ECM was an example of the application of Stealth/Surprise SEAD intended as it was to reduce the effective range of the IADS' ground-based air surveillance radar.[44]

In addition to the Mandrel effort performed by 199 and 803 Squadrons to help conceal the airborne element of Overlord from discovery, Bomber Command made efforts to cause significant disruption to *Luftwaffe* radio communications. Much like the deployment of the

[42] AIR 14/2348.
[43] Baltrusaitis, *Quest for The High Ground*, p.3.
[44] Dougherty, *Defense Suppression*, pp.25-27.

Mandrel Screen, this effort would be mounted to protect the airborne operation from interference by *Luftwaffe* fighters.[45] As Harris noted:

> The ABC aircraft were expected to protect all the airborne forces and aircraft concerned in the Overlord operation, by patrolling across the expected line of approach of enemy fighters and jamming their VHF communications.[46]

The disruption of *Luftwaffe* radio communications employed the ABC and Ground Cigar ECMs. Although the lion's share of Bomber Command's EW efforts against the IADS were the responsibility of 100 Group, the Command did have an additional EW organisation in the form of 101 Squadron which, as well as deploying ABC, was tasked with performing conventional bombing missions. While the ground-based version of ABC, codenamed Ground Cigar, was sufficient to jam *Luftwaffe* VHF radio communications between the UK and the Dutch coast, ABC was necessary to jam these communications while the bomber stream was flying over Germany and occupied Europe.[47] As the previous chapter illustrated, ABC ECMs in service with 100 Group could be used to jam *Luftwaffe* radio navigation systems for directing night fighters. In the prelude to Overlord, ABC jamming was performed by 101 Squadron, and by 214 Squadron in addition to its Mandrel Screen tasks. Both these units were used to jam *Luftwaffe* radio communications in the Normandy-Paris area. This operation had an added utility as it was intended to persuade the enemy that an airborne operation was being performed in the vicinity of Boulogne-sur-Mer to the east of Normandy.[48]

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[45] 'Letter from DCAS to CAS Detailing 100 Group Operations Over the Past Fortnight, 13 June 1944', AIR 2/7309.
[46] Grehan, Mace, *Bomber Harris*, p.285.
[47] AIR 20/8070, p.3.
[48] AIR 41/56, p.85.

In terms of the *modus operandi* of the ABC operation, aircraft from 101 and 214 Squadrons orbited two areas, each of which was spaced 43.4nm (80.4km) apart, with a 4.3nm (eight kilometres) radius, positioned 8.6-13.1nm (15.9-24.2km) inland between Dieppe and the mouth of the Somme river on the French Channel coast to the east of Normandy. This jamming was to be provided from 0000 hours on 5 June until dawn on 6 June.[49] The Lancaster-BI/III aircraft of 101 Squadron were each fitted with three ABC ECMs which between them would cover a bandwidth of 38MHz to 42MHz. An extra crewmember was carried in each aircraft to perform 'spot' ABC jamming, by which specific frequencies in use by *Luftwaffe* radio communications were jammed as and when they were discovered. 101 Squadron deployed a total of 24 aircraft, with 214 Squadron deploying five, the maximum number of ABC-equipped aircraft possessed by the latter squadron at the time.[50]

The official record denoted that a significant number of *Luftwaffe* fighters were scrambled into the area where the ABC screen was operating, with the impression that the aircraft from 101 and 214 Squadrons performing the ABC jamming were in fact Main Force bombers mounting attacks. Despite experiencing significant jamming when they entered the area where the Main Force was supposedly located, the fighters returned to their radio beacons and were ordered to continue their detection and interception of the Main Force.[51] These fighters continued operating within the area where ABC jamming was being performed which resulted in the combined 101 and 214 Squadron force destroying one enemy aircraft, and damaging two more, for the loss of a single 101 Squadron Lancaster-BI/III.[52]

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[49] 'AEHF RCM Requirements, Report on Meeting held at Bomber Command on the 11 March, 1944, Air Commodore Constantine in the Chair', AIR 20/4715.
[50] AIR 41/56, p.237.
[51] *Ibid.*, p.239.
[52] *Ibid.*

Like the deployment of ABC, Ground Cigar was used to jam hostile fighter communications in the 38MHz to 42MHz waveband.[53] In particular, a Ground Cigar station located near Brighton, on the south coast of England, was tasked with providing radio jamming over northern France. That said Bomber Command was not optimistic regarding the efficacy of Ground Cigar. During the meeting held at Bomber Command headquarters on 11 March 1944 to discuss the EW support Bomber Command would provide it was expressed that Ground Cigar was expected to be 'of little use'.[54] While the success, or otherwise, of Ground Cigar receives no further discussion in official records, the efforts of 101 and 214 Squadrons regarding ABC were judged to have been successful 'and all evidence suggested that their efforts were of great value'.[55] The implementation of ABC jamming by 101 and 214 Squadrons, and the Ground Cigar jamming, was also performed at the Localised SEAD level given that they occurred across a specific area during a specific timeframe: The jamming was performed for one night only with the intention of jamming *Luftwaffe* radio communications solely for this period i.e. during the airborne operation in support of Overlord, with the jamming occurring in the vicinity of Boulogne-sur-Mer above which ABC orbits were flown. While ABC/Ground Cigar jamming was performed at the Localised level, it applied the Manoeuvrist approach.[56] The employment of ABC/Ground Cigar jamming clearly corresponds to this approach as its intention was to create a deception, in this case, to convince *Luftwaffe* fighters, and their controllers, that the airborne operation was being performed in the vicinity of Boulogne, and not in Normandy.

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[53] *Ibid.*, pp.238-239.
[54] 'AEHF RCM Requirements, Report on Meeting held at Bomber Command on the 11 March, 1944, Air Commodore Constantine in the Chair', AIR 20/4715.
[55] AIR 14/2344.
[56] Bellamy, 'Manoeuvre Warfare', p.541.

The deployment of Mandrel, ABC and Ground Cigar were all indicative of a reactive Bomber Command EW policy. The Command was fully aware of the danger which the IADS could pose to the airborne element of Overlord. Continued bombing operations against targets in Germany and occupied Europe had left the Command with a considerable respect for the efficacy of the IADS, and of the radar and radio communications/navigation systems upon which it relied. Ultimately the RAF, and Bomber Command more specifically, was in no doubt as to the lethality of the IADS notably in terms of the significant ground-based air surveillance radar coverage within and without the invasion area which could alert the *Luftwaffe* to the incoming package of transport aircraft and gliders supporting the airborne invasion, and the radio communications which could then be used to aid the interception of these aircraft.

Conclusions

A number of volumes discussed the Command's EW efforts and SEAD posture in support of Overlord. Ostensibly, these examined its efforts to jam *Luftwaffe* radar and radio communications prior to, and during, the invasion's amphibious and airborne landings, and the *modus operandi* regarding the use of ECMs such as Mandrel, Window and ABC. The existing literature has some limited discussion of the deliberations of Bomber Command's leadership regarding the role that it would play in opposing the IADS, although this does not extend beyond the discussions which took place concerning the potential threat posed by *Luftwaffe* fighters, with the focus on the Command's kinetic air-to-air operations *vis-à-vis* this threat. Similarly, the literature focuses on kinetic attacks made against *Luftwaffe* radar targets, while the ground-based jamming efforts against the IADS are all but ignored, as is the importance of the Command's EW experience accrued during its support of Overlord as regards its EW activities against the *Luftwaffe* IADS for the rest of the war. This is important, as the Command's activities during the invasion constituted a 'dress rehearsal' for those which it would bring to bear against the IADS during the remainder of the conflict.

The EW policy pursued by Bomber Command prior to and during Overlord was overwhelmingly reactive. It was, quite simply, a reaction to the threat posed by the *Luftwaffe* IADS in the Normandy theatre, and would be enacted to reduce the threat that this posed to the airborne dimension of Overlord to the fullest extent possible. This reactive EW policy would be enacted at the Campaign and Localised SEAD levels. Bomber Command's leadership were emphatically Campaign SEAD minded regarding the assistance that the Command would provide to Overlord. Interestingly, kinetic attacks against radar stations were performed during the preparatory phase of the invasion with such operations performed by fighter-bombers. The use of these aircraft might explain why a broader kinetic SEAD effort against the radar stations and GCI centres which underpinned the IADS was not undertaken to support the strategic air campaign. The size of such targets meant that they would need to be attacked from low altitude; impractical for the heavy bombers supporting the strategic air campaign, while the fighter-bombers which supported such attacks on the eve of Overlord would have lacked the range to hit such targets in Germany and elsewhere in occupied Europe from the UK at this point in the war. Meanwhile, lighter aircraft supporting the strategic air campaign such as the Mosquito may have been deemed more suitable to assist other elements of the strategic air campaign such as Intruder operations. Secondly, the use of fighter-bombers equipped with RWRs to locate and destroy *Luftwaffe* FC/GCI and ground-based air surveillance radar, underlined the RAF's pioneering of a SEAD tactic which remains commonplace today.

While the Command's leadership was Campaign SEAD minded the electronic war against the IADS would be performed at the Localised level. During the period under examination, the Group introduced new ECMs into service, notably the Jostle-IV system which was deployed as a result of a reactive EW policy concerning the threat posed by *Luftwaffe* HF and VHF radio communications, and which would be deployed to perform Localised SEAD through the application of Mass. The Mandrel Screen implemented to protect the airborne element of the invasion was also an example of Localised SEAD, although in this instance being applied using the Mass and Stealth/Surprise SEAD methods. Meanwhile, the ABC and Ground Cigar jamming efforts performed by the Command were examples of Localised SEAD, but with this being applied using the Manoeuvrist approach. Ultimately, the Command's EW policy *vis-a-vis* Overlord was reactive with its leadership having a Campaign SEAD mindset with regards to the *Luftwaffe* IADS, with their vision implemented at the Localised level using a combination of Mass, Manoeuvre and Stealth/Surprise approaches.

The Command's use of ECMs to support Overlord had an effect which outlasted the actual invasion and its immediate aftermath. The operation had taught the Command new means by which to employ ECMs in support of the Main Force for the duration of the war. As Harris observed, one of the most important results was a realisation that the Mandrel Screen could be used to either mask the approach of Bomber Command aircraft, or to create unnecessary alerts to force the *Luftwaffe* to scramble its fighters, and to hence waste fuel, and increase aircraft wear and tear and aircrew effort; 'unnecessary activity and wastage among enemy defences' as this was dubbed by Harris. Moreover, the Mandrel Screen could be used in conjunction with the dispersal of Window, with the latter being used to both jam radar, and to create the false appearance of the Main Force, while reducing radar detection range. Harris observed that this ‘reduction in early warning caused by the Mandrel Screen gave the fighter controllers so much less time to appreciate genuine and feint raids and make their dispositions accordingly’.[57] Such techniques would now be brought to bear against the *Luftwaffe* IADS in the final year of the war.

[57] Grehan, Mace, *Bomber Harris*, p.285, p.294.

CHAPTER SEVEN

BOMBER COMMAND ELECTRONIC WARFARE POLICY AND SUBSEQUENT SUPPRESSION OF ENEMY AIR DEFENCE POSTURE: MAY TO NOVEMBER 1944

Introduction

While the previous chapter examined Bomber Command's EW policies and SEAD posture immediately prior to and during Operation Overlord, this chapter will examine the Command's EW policies and SEAD posture during the penultimate six months of the war. It will commence by detailing Bomber Command's strategic air campaign priorities at this point in the conflict performed alongside its support of Overlord, as examined in Chapter Six. The chapter will continue by noting that the *Luftwaffe* IADS was still capable of inflicting losses on the Command and that because of this Bomber Command continued its EW efforts to reduce the effectiveness of the IADS by introducing EW techniques such as the Mandrel Screen and the SWF. The changing situation on the ground as the Allies liberated territory under German occupation also had an impact on the IADS, the chapter will observe, by depriving it of radar coverage and fighter bases. The chapter will note that during this timeframe the Command's knowledge of *Luftwaffe* AI radar increased significantly, allowing the development of new ECMs to this effect. EW efforts were performed during the period under investigation alongside OCA efforts, although the chapter will note that the emphasis placed on OCA reduced from September 1944. While the emphasis on OCA declined, the EW efforts of Bomber Command did not diminish with a heightened focus on degrading the efficacy of *Luftwaffe* AI radar. Similarly, efforts were taken to move 80 Wing's ground-based ECMs to the continent to place them in jamming range of *Luftwaffe* radar, and radio communications/navigation systems following the liberation of France and Belgium.

Summer 1944: Fighter Defences Sharpen

Against the backdrop of Overlord the strategic air campaign continued while the Allies performed their airborne and amphibious landings in Normandy followed by the subsequent Normandy Breakout in August. Prior to 6 June, as May 1944 was drawing to a close, the Allied High Command was already contemplating the priorities of the strategic air campaign once the invasion concluded and Allied land forces had definitively established themselves on the continent. The British Chiefs of Staff wished for the focus of the strategic air campaign to prioritise the destruction of Germany's oil industry, in particular four large synthetic oil plants located in the Ruhr Valley. By 10 June, the Supreme Headquarters Allied Expeditionary Force [SHAEF] which had commanded all Allied forces in northwest Europe since late 1943, and would continue to do so until the end of the Second World War in Europe, issued plans for the strategic air campaign to be directed against Germany's oil supplies. Destroying such targets would have the dual benefits of denying oil supplies to German forces arrayed against the Allies as they consolidated their foothold in Normandy, and to German forces deployed in other theatres, notably on the Eastern Front.[1] This emphasis on oil targets triggered opposition from Harris which he argued was a distraction from the employment of the Command's aircraft to attack Germany's industrial cities, and that the attack of oil targets would have meant forsaking a targets 'which (were) indisputably doing the enemy enormous harm for the sake of prosecuting a new scheme the success of which was far from assured'. Although with

[1] AIR 41/56, p.56.

hindsight he considered the effort against oil to be a complete success, he argued that 'it could not have been so without the co-operation of Bomber Command'.[2]

In addition the Command was to continue its attacks against transportation targets notably important rail junctions and rail targets, so as to force the Germans to become ever more reliant on road transport, which in turn would be vulnerable to the availability of oil. Although the first priority for the combined bomber fleets of the USSTAF and Bomber Command was to support ongoing operations in Normandy under SHAEF's auspices, its commander, General Dwight D. Eisenhower stipulated that when these aircraft were not directly required to support such operations, the strategic air campaign should continue to attack oil and aircraft production targets, and Germany's automotive industry so as to reduce military vehicle production. Regarding aircraft production targets, the Air Ministry ordered that these targets should include aircraft and aircraft component production, fuel facilities; airfields and aircraft storage areas; aircraft engine factories and urban centres associated with aircraft production.[3]

Figure XII – Bomber Command Losses for Sorties Despatched: May - November 1944

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
May-44	Night	11353	274	2.4%
	Day	16	0	0.0%
	Total	**11369**	**274**	**2.4%**
Jun-44	Night	13592	293	2.2%
	Day	2371	12	0.5%
	Total	**15963**	**305**	**1.9%**
Jul-44	Night	11500	229	2.0%
	Day	6298	12	0.2%

2 Harris, *Bomber Offensive*, p.182.
3 AIR 41/56, p.56, p.51.

	Total	**17798**	**241**	**1.4%**
Aug-44	Night	10013	186	1.9%
	Day	10271	35	0.3%
	Total	**20284**	**221**	**1.1%**
Sep-44	Night	6428	96	1.5%
	Day	9643	41	0.4%
	Total	**16071**	**137**	**0.9%**
Oct-44	Night	10193	75	0.7%
	Day	6713	52	0.8%
	Total	**16906**	**127**	**0.8%**
Nov-44	Night	9589	98	1.0%
	Day	5055	41	0.8%
	Total	**14644**	**139**	**0.9%**

Source - 'Appendix 10' in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Nevertheless, the focus on these targets came at a cost to Bomber Command. Despite Overy's argument that the Allies had secured air supremacy over Germany and occupied Europe by June 1944 with the 'attrition cycle … for the moment, complete', losses of bombers continued following Overlord as the *Luftwaffe* reorganised its fighter defences, although as figure XII illustrates losses as a percentage of sorties despatched during the period under examination progressively declined from 2.4 percent in June to 0.9 percent by November.[4] The reorganisation of *Luftwaffe* fighter defences took the form of a redeployment of fighters from Germany into France to be within closer striking distance of the tactical and strategic aircraft supporting subsequent Allied efforts to enlarge the ground footprint in Normandy.[5] Furthermore, the *elan* of *Luftwaffe* fighter pilots was undiminished and Overy reflected that its aircrews 'continued with almost reckless bravery to pit their tiny strength against the air armadas'. Germany also continued to possess significant AAA defences, which Overy stated exceeded fifty thousand heavy and light AAA guns deployed around major German industrial

[4] Overy, *The Bombing War*, p.378.
[5] AIR 41/56, p.79.

targets.[6] For example, Bomber Command suffered loss rates of two percent on bombing sorties, mine-laying and bomber support tasks in June, which continued into July. Additionally, the number of radio beacons around which *Luftwaffe* fighters could orbit while they awaited vectoring towards targets was increased in coastal regions so as to engage Allied aircraft flying from the United Kingdom in support of post-Overlord land operations. Of particular concern to Bomber Command was the *Luftwaffe's* intensification of its fighter defences over the Ruhr Valley. Given that the summer nights in Western Europe were shorter in June, July and August compared to the rest of the year, the Command was deprived of the cover of darkness to help protect its aircraft during long sorties against targets deep in Germany. This subsequently restricted it to more westerly targets hence the *Luftwaffe* could afford to strengthen its defences around the Ruhr without necessarily weakening fighter defences around other potential targets in the east of Germany. As a consequence of these actions, during three nights in June, Bomber Command lost 11.3 percent of its aircraft during operations; a total of 94 bombers.[7]

The Mandrel Screen and SWF

As a response to these losses, efforts to protect the Command's aircraft continued. Although it had been in use since December 1942 to protect Main Force aircraft, 100 Group's 199 and 803 Squadrons had employed the Mandrel ECM in the form of a screen for the first time during Overlord to jam FuMG-80 radars. Deployable as both a ground-based and airborne ECM, when used in an airborne fashion, the Mandrel ECM was capable of reducing the

[6] Overy, *The Bombing War*, p.378.
[7] 'Appendix 13: Sorties Despatched, Aircraft Lost, Tons Dropped and Number of Mines Laid by Type of Operation (Monthly)', AIR 41/56, p.3, p.79.

detection range of such radar from around 156.3nm (289.6km) to 34.7nm (64.3km).[8] Mandrel had originally outfitted individual Command aircraft, as opposed to solely being the preserve of those operated by 100 Group but by the second half of 1944, it was a victim of its own success. The ability of the ECM onboard individual Command aircraft to jam *Luftwaffe* ground-based air surveillance radars had been such that it had compelled the force to move the transmission frequencies of the FuMG-80 radar out of the waveband that could be jammed by existing Mandrel ECMs. This frequency extension meant that the ECMs onboard Main Force aircraft could no longer successfully jam the FuMG-80 and that new versions of Mandrel which could jam these frequencies could not be adequately accommodated onboard individual bombers. Instead, the *Luftwaffe's* ground-based air surveillance radars would be jammed using dedicated 100 Group aircraft each carrying several Mandrel ECMs to ensure that the entirety of the radar's waveband was jammed to the fullest extent possible.[9]

The removal of Mandrel from the Main Force and its confinement to 100 Group enabled it to generate a jamming screen. The *modus operandi* of the Mandrel Screen called for several aircraft equipped with the ECM to be flown in such a way as to draw an electronic 'blanket' in front of the radars thus preventing them from seeing what was happening behind the screen.[10] Typically, a Mandrel Screen could be around 86.8nm (160.9km) in length.[11] Several 100 Group units supported the Mandrel Screen effort notably 171 and 199 Squadrons; and the USAAF's 803 Squadron. Although the ECM was designed to jam the FuMG-80, it could also

[8] AIR 20/1568.
[9] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944', AIR 20/8071, Radar and Radio Countermeasures (Code 61): Radio countermeasures (RCM): devices, 1943-1945.
[10] AIR 41, pp.77-78.
[11] 'AVM Addison, Brief Survey of the Operational Functions of No.100 Group, 4 November 1944', AIR 14/2657.

be used against the *Luftwaffe's* Gema FuMG *Freya Fahrstuhl*, Gema/Siemens/Lorenz FuMG-404 *Jagdschloss*, FuMo-51 and FuMG-402 ground-based air surveillance radars.[12]

The screen could be employed in a number of ways, one of which was to intentionally deactivate it allow the radars being jammed to temporarily see a force of aircraft flying behind. This force of aircraft could be flying towards a false target, thus persuading the *Luftwaffe* radar operators that they had momentarily seen 'real' Main Force aircraft, and to discern the intended target of these aircraft based on their vector.[13] This was used with great effect with the SWF discussed below. Typically, the Mandrel Screen would be deployed parallel to the Belgian or Dutch coasts, flying circuits which could be moved closer to, or further away from, *Luftwaffe* ground-based air surveillance radar coverage to cause added confusion.[14] A further benefit of the screen was that its mere activation was often sufficient to force the *Luftwaffe* to scramble fighters in anticipation of a Main Force attack. For example, on 16 separate occasions in August, the Mandrel Screen was activated opposite the Pas de Calais on the French Channel coast. *Luftwaffe* fighters would be directed to the Pas de Calais in anticipation of the Main Force's attack developing from this area, while in reality the Main Force would outflank the fighters on their way to their targets.[15] Following its use in support of Overlord, the Mandrel Screen made its debut supporting Bomber Command in the strategic air campaign on 16/17 June, with 100 Group's 199 and 803 Squadrons employing the screen.[16] Addison summed up the contribution that the screen made to Main Force operations noting that:

[12] 'AVM Addison, Report on the Working Radio Countermeasures, 30 July 1944', AIR 14/2657.
[13] AIR 41, pp.77-78.
[14] 'AVM Addison, Report on the Working Radio Countermeasures, 30 July 1944', AIR 14/2657.
[15] AIR 14/2911.
[16] AIR 41, pp.77-78.

> Stated briefly, the function of the screen is to deny to the enemy a knowledge of the areas and times of assembly of our forces, the directions in which our attacks develop, and conformations and deployment of our forces.[17]

The Mandrel Screen was not the only mechanism at 100 Group's disposal for jamming ground-based air surveillance radars. The Window ECM, first used in July 1943, was pressed into service following Overlord to support the Mandrel Screen. Bomber Command organised its provision of Window into a dedicated force of aircraft (comprising 171, 199, 214 and 223 Squadrons) tasked with dispersing the countermeasure over enemy territory. The SWF would usually comprise up to 20 aircraft, and would disperse Window at a high rate. The intention was for the force to appear as the Main Force dispersing the ECM in its usual fashion.[18] The SWF performed its first operation on the night of 14/15 July supporting a Bomber Command attack on Kiel, on Germany's Baltic coast, and its effect was summarised by 100 Group's Fortnightly Progress Report:

> (B)omber aircraft attacking Kiel were successfully hidden by the Mandrel Screen until they were almost in the target area, and a windowing 'spoof' consisting of nine aircraft, which went 15-20 miles (13nm/24.1km-17.3nm/32.1km) inland over the Dutch Islands was reported as 100 aircraft, the spearhead of a bomber formation. Four bomber aircraft were lost out of a force of 620 on Kiel.[19]

The SWF could be employed in a number of ways; by simulating a second bombing force, separate to the Main Force acting independently and flying on its own route; alternatively, the SWF could accompany the Main Force, and then head towards a false target, having the advantage of splitting the *Luftwaffe* fighter force sent to intercept the Main Force; or to saturate a specific area on the Main Force's route, or around a target to frustrate *Luftwaffe*

[17] 'Memo from AVM Addison, 8 August 1944', AIR 14/736, Number 100 Group BS Fighter Command: RCM aspects.
[18] 'AVM Addison, Brief Survey of the Operational Functions of No.100 Group, 4 November 1944', AIR 14/2657.
[19] '100 Group Fortnightly Progress Report No.15', AIR 14/2348.

IADS radar coverage. One or more of these SWF tactics could be employed on any specific night of Main Force operations.[20] As Addison noted the SWF's strength was noteworthy when it was used near the coast of Western Europe as 'we cannot keep up this deception over land, since the German Observer Corps would soon see through it.' However, Addison added that, 'we can sometimes use if to give the enemy the notion that a large force is approaching a particular part of his coast, and so induce him to marshal his fighters to meet it'. The fighters would 'take the bait' as the SWF could usually convince IADS radar operators that a force of 50 to 200 Bomber Command aircraft was heading towards Germany.[21] The SWF could have added impact in this regard as it was sometimes used in conjunction with De Havilland Mosquito fighters which would add a measure of realism, as they would accompany the Main Force, and attack any scrambled fighters, causing additional attrition to the *Luftwaffe* fighter force. A further variation of this latter tactic saw the SWF incorporate a mixed force of Mosquito fighters and fighter-bombers to perform an attack on a specific target to add credibility to the illusion that an actual Main Force operation was underway.[22]

The use of the SWF enabled 100 Group to perform creative deceptions against the IADS. Writing in July 1944 Addison discussed the use of the SWF in conjunction with the Mandrel Screen. The concept of operations in this regard was for the Mandrel Screen to take up positions over the North Sea and to jam *Luftwaffe* ground-based air surveillance radars. The screen, Addison noted, would be mounted regardless of whether an actual Main Force attack was occurring. To create the illusion that such an attack was underway the SWF would fly through the screen dispersing its countermeasure. This would create the appearance for *Luftwaffe* radar operators that the Main Force was emerging through the Mandrel Screen, and

[20] AIR 41, p.78.
[21] 'AVM Addison, Report on the Working Radio Countermeasures, 30 July 1944', AIR 14/2657.
[22] AIR 41, p.197.

that an attack was imminent. Fighters would be scrambled to meet this spoof Main Force, only to discover that no attack was taking place. This tactic accorded well with Addison's intention to progressively wear down the IADS. Eventually, the *Luftwaffe's* Pavlovian reflex would subside, and fighters would no longer be scrambled to meet the non-existent Main Force.[23] This lack of interest on the *Luftwaffe's* part would eventually pay dividends:

> (O)n the night of 25/26th July, when a real bomber force did get through the screen, the enemy was not prepared to play. He had very little time to recover from his mistake, for instead of having his usual hour's warning of our approach across the North Sea in which to make up his mind, he did not apparently see our force until after it had crossed the Dutch coast.[24]

The SWF forced the *Luftwaffe* to scramble fighters on a number of occasions, as 100 Group's Review of Operations records:

> (C)onsiderable success was achieved, however, on at least four occasions, when the enemy were very much deceived as to the size of the force, and diverted fighters which could well, from the Hun viewpoint, have been put to better use. The force was, at this period, routed only over sea routes, turning back when still a little short of the enemy coast.

Despite *Luftwaffe* fighters scrambling to intercept the SWF on several occasions, it would husband its fighter strength and simply refused to indulge the SWF's deception. As a result, by November, the *Luftwaffe* adopted a policy of maintaining its fighters over the Ruhr Valley to meet Bomber Command attacks. This was also a consequence of Bomber Command dedicating its efforts to attacks in the Ruhr during the short summer nights of 1944. Nonetheless, the SWF was employed to jam *Luftwaffe* radars in support of Main Force attacks

[23] 'AVM Addison, Report on the Working Radio Countermeasures, 30 July 1944', AIR 14/2657.
[24] *Ibid.*

in the Ruhr Valley, alongside the Mandrel Screen.[25] During such operations, the Screen would shield the approach of the Main Force from the *Luftwaffe's* ground-based air surveillance radars. This would reduce the available warning and interception time for the fighters before the bombers reached their targets. The SWF would then accompany the Main Force to disperse a significant quantity of Window to hide it from *Luftwaffe* FC/GCI and AI radar to the fullest extent possible.[26]

On the one hand, the introduction of the Mandrel Screen was a clear example of SEAD being practiced at the Localised level.[27] As the screen was often mounted in conjunction with a Main Force operation, it clearly conformed to this definition as it was designed to protect the Main Force for the duration of its mission. Moreover, as the screen would be deployed to mask *Luftwaffe* radars in a particular area, this meant that it conformed to the Localised SEAD level definition. Yet the Mandrel Screen was also an example of SEAD being performed at the Campaign level: It was mounted not only when a Main Force operation was taking place, but on other occasions when no such mission was occurring, the aspiration being to continually tire the *Luftwaffe* in accordance with Addison's intentions to this effect articulated in his 17 April letter to Dalton-Morris.[28] Regarding its method of application, the Mandrel Screen, when being used to protect the Main Force, was an example of the Manoeuvrist application of SEAD.[29] The screen was deployed to enable the Main Force to use routes which may have been less heavily defended, or which became less heavily defended as a consequence of the *Luftwaffe's* attention being distracted towards an area away from Main

[25] AIR 14/2911, p.27.
[26] 'AVM Addison, Report on the Working Radio Countermeasures, 30 July 1944', AIR 14/2657.
[27] Baltrusaitis, *Quest for The High Ground*, p.3.
[28] 'Letter from Addison to Air Commodore L. Dalton-Morris, Command Signals Officer, HQ Bomber Command, 17 April 1944', AIR 14/2657.
[29] Dougherty, *Defense Suppression,* p.25 and Bellamy, 'Manoeuvre Warfare', p.541.

Force activity. In a further example of its Manoeuvrist orientation, the Mandrel Screen would exploit deception by misleading *Luftwaffe* radar operators as to the location of the Main Force. The use of the screen was also an example of the Stealth/Surprise SEAD approach as it worked to reduce the detection range of the *Luftwaffe's* ground-based air surveillance radar to 'the point where they are essentially nullified'.[30] Finally, the adoption of the Mandrel Screen was an example of reactive Bomber Command policy as it was a reaction to the threat posed by the tactics, techniques and procedures used by the *Luftwaffe* fighter force during the summer and autumn of 1944.

Like the Mandrel Screen, the SWF was an example of SEAD performed at the Localised level as it was intended to jam *Luftwaffe* radars for a specific time when the Main Force may have been active, or when the Mandrel Screen was being used. It also accorded to this definition as the SWF was designed to jam *Luftwaffe* radars in a specific area. Furthermore, the SWF was an example of Campaign level SEAD as it was intended to tempt the *Luftwaffe* into constantly reacting to the use of the ECM under the impression that it was the Main Force. In this regard it too was contributing to Addison's goal of progressively wearing down the strength of the IADS. Regarding the method of SEAD application the SWF conformed to the Manoeuvrist approach as it was designed to decieve *Luftwaffe* radar operators that the cloud of Window appearing on their screens was being dispersed by the Main Force. The combination of the SWF and Mandrel Screen was the EW equivalent of the 'one-two punch' in boxing where two blows are delivered in rapid succession to first blind and then strike the opponent, with the screen shortening the sight, if not altogether blinding the FuMG-80 radars, and the dispersion of Window causing jamming. Harris argued that the advent of the SWF/Mandrel Screen were

[30] Dougherty, *Defense Suppression*, p.25.

the two EW approaches which 'were chiefly responsible for reducing the enemy night defensive system to a state of impotence, from which it never recovered'.[31]

June 1944: The Oil Offensive Intensifies

The Mandrel Screen and SWF would play an important role in helping to protect the Command's aircraft as it prosecuted German oil targets in earnest from June, despite the opposition of Harris. The Command performed its first attack against an oil target on 12 June, with a further five hit in July and four attacked in August. Nevertheless, despite the focus of the strategic air campaign against oil, the campaign was also directed against the launch sites of Germany's V-1 surface-to-surface missiles which had commenced attacks against targets in the United Kingdom on 13 June, necessitating a redirection of Bomber Command's efforts against launch facilities particularly in the Pas de Calais.[32] Meanwhile German pressure against the Allied presence in Normandy was increasing following the invasion, requiring Bomber Command to be employed against German land forces deployed in that theatre. These targets were hit in tandem with continuing Command attacks against the German oil industry as described above.

The SWF and Mandrel Screen were not the only approaches brought to bear by Bomber Command to reduce the potency of the IADS. Much as it had been since its formation in November 1943, 100 Group's role remained the reduction of *Luftwaffe* fighter strength to protect the Command's aircraft during their sorties.[33] This would be achieved using three

[31] Grehan, Mace, *Bomber Harris*, p.289.
[32] AIR 41/56, p.57, pp.51-52.
[33] 'Minutes of Conference at Headquarters Bomber Command on 20 May 1944 to discuss the Operational Role and Training Requirements of SD Bomber Support Squadrons', AIR 14/735, No 100 Group BS Fighter Command: support for bomber Offensive.

distinct, but related, approaches; the kinetic destruction of fighters in the air and on the ground using 100 Group fighters; the jamming of the IADS radar, and radio communications/navigation systems supporting the *Lufwaffe's* fighters; alongside the gathering of ELINT concerning the IADS to enable the development and application of new ECMs.[34] The primary role of the Group was to apply these three approaches to protect the Main Force during operations.[35]

The Main Force was usually organised in a 'stream' of bombers 86.8nm (160.9km) long, 8.6nm (16km) wide and 0.8nm (1.6km) in height, typically containing up to 1,000 aircraft. With such a large formation of aircraft the imperative was to prevent the *Luftwaffe* discovering the Main Force in the first place, as once discovered it was difficult to prevent its penetration by *Luftwaffe* fighters. Preventing the discovery of the Main Force would be achieved by denying the *Luftwaffe* radar coverage and jamming its radio communications/navigation systems.[36] Although 100 Group was to apply kinetic and electronic means to protect Main Force aircraft in July Addison reiterated his intention, as articulated in his 17 April letter to Dalton-Morris, to use the Group's efforts to hasten the attrition of the *Luftwaffe* IADS, saying that these efforts should focus on, 'the wearing down of the Huns by coaxing (their fighters) to fly on as large a scale as possible even on nights when the 'heavies' (Main Force aircraft) are not operating'.[37]

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[34] *Ibid.* and 'Air Cdre CS Cadell, Brief Survey of the Functions of the Aircraft of No.100 Group in Support of Bomber Command, 3 November 1944', AIR 20/9037, Royal Air Force: Groups (Code 67/31): 100 Group: Organisation, 1943-1945.
[35] 'Future Bomber Protection, 6 July 1944', AVIA 7/3773, Radio countermeasures in Bomber Command and 100 Group Nightfighter and Intruder operations.
[36] *Ibid.*
[37] 'No.100 Group Operations Memorandum, Bomber Support Policy, May 1944', AIR 14/2657.

Addison's desire to reduce the strength of the IADS would receive an unexpected benefit in mid-July 1944, when a *Luftwaffe* Junkers Ju-88G fighter accidentally landed at RAF Woodbridge in Suffolk. Usefully for 100 Group this aircraft was carrying the FuG-220 *Lichtenstein* SN-2 AI radar which had commenced production in September 1943. This would allow the development of new ECMs to be used against it, such as the Window-NB ECM which would be deployed from July. In tandem with the arrival of the Ju-88G Bomber Command benefitted from the changing situation on the ground in France. The advance of the Allied armies across France following the Normandy Breakout in August and the liberation of France one month later significantly changed the tactical situation for the Command as the *Luftwaffe* lost its chain of ground-based early warning radars along the French Channel and Atlantic coasts, depriving it of valuable warning time *vis-à-vis* incoming hostile aircraft. This loss of territory was increased for the *Luftwaffe* following Operation Dragoon, the Allied invasion of southern France on 15 August, which saw the retreat of the German Army Group G to the Vosges Mountains in eastern France, close to the German border, helping to precipitate the liberation. Although the Window ECM was used to support the airborne element of the Dragoon landings, this effort did not involve Bomber Command, instead employing the RAF's 216 Squadron; an airlift unit tasked with deploying the ECM, and hence its further discussion is beyond the scope of this thesis.[38] The loss of territory for radar stations meant that the maximum warning distance for the *Luftwaffe* regarding incoming Allied aircraft was reduced to 86.8nm (160km) from Germany when Command aircraft approached from France and Belgium (most of which was liberated by September 1944, with much of the Netherlands remaining under German occupation); greatly reducing the reaction

[38] AIR 41, p.129, p.156, p.247

time for *Luftwaffe* fighters. Coupled with this the *Luftwaffe* lost airfields in France making it harder to intercept Bomber Command aircraft before they reached their targets.[39]

Offensive Counter Air

Beyond EW, other tactics were incorporated into Bomber Command's operations to reduce losses including the adoption of low altitude flight for as much of the ingress and egress to and from targets as possible to reduce the time during which Bomber Command aircraft would be exposed to ground-based air surveillance and FC/GCI radar coverage; the maintenance of radio silence by prohibiting the use of Bomber Command's H2S navigation radar, lest the *Luftwaffe* detect the RF emissions from aircraft equipped with it; the use of OCA measures in form of high and low altitude night fighters to escort the Main Force and combat air patrols in areas where *Luftwaffe* fighters were expected, plus Intruder attacks against *Luftwaffe* fighter bases, and aircraft landing and taking off from these airfields.[40]

To reduce the losses being suffered by Bomber Command, which averaged two percent of sorties despatched for June and July, a major OCA effort was planned by the Command to reduce *Luftwaffe* fighter strength. To this end, Operation Butterscotch involved the heavy bombers of the USSTAF, Bomber Command and the USAAF and RAF tactical air forces. Earmarked to be performed after 10 July when weather conditions permitted, Butterscotch would see Bomber Command tasked with attacking nine fighter airfields in Belgium and the Netherlands using 100 aircraft. The USSTAF Eighth Air Force would meanwhile attack 17 fighter airfields with 108 aircraft. The operation was finally performed on 15 August and its

[39] AIR 41/56, p.129.
[40] *Ibid.,* p.131.

intention was three-fold; to destroy fighters and their support facilities, crater runways and attack any additional targets of opportunity discovered during the conduct of the raids. Concurrently with Operation Butterscotch, Bomber Command benefited from the changing situation on the ground. The Normandy Breakout that had commenced with the US-led Operation Cobra on 25 July enabled the US Army to push south-eastwards out of Normandy, capture Brittany in the southwest and move eastwards towards Paris. Meanwhile the Anglo-Canadian Operation Bluecoat launched on 30 July kept German armour fixated on the Anglo-Canadian segment of eastern Normandy thus easing the path of the US advance during Cobra. Following the Breakout, Paris was liberated on 25 August, leading to the liberation of most of France *sans* the Alsace-Loraine region on the northeast border with Germany which remained in the hands of the latter. The result of the liberation was that Command aircraft could now be routed to and from their targets in Germany over friendly territory greatly reducing the time that they would be exposed to *Luftwaffe* fighters. This reduction in the territory under German control and the airspace that *Luftwaffe* fighters could defend, allowed Bomber Command to commence daylight sorties against targets in Germany on 27 August, with an attack against the Meerbeck synthetic oil plant in the Ruhr. Furthermore, the German loss of territory enabled the Allies to station fighter escorts for strategic bombers closer to Germany. For example the Bomber Command raid against the Meerbeck plant was protected by Supermarine Spitfire fighters from the RAF's 10, 11 and 12 Groups.[41] This combination of friendly territory acquisition and the intensification of Command fighter defences particularly during daytime missions had the effect of reducing Bomber Command losses to 1.1 percent for all sorties despatched in August.[42]

[41] *Ibid.,* p.62, p.96, p.99, p.101.
[42] 'Appendix 13: Sorties Despatched, Aircraft Lost, Tons Dropped and Number of Mines Laid by Type of Operation (Monthly)', AIR 41/56, p.3.

Yet, despite the use of OCA and EW, Addison remained concerned about the strength of the IADS, and in early August conveyed his worries that Bomber Command could begin to suffer significant losses as the winter of 1944 approached. In a memorandum to Bomber Command headquarters on 2 August, he warned that:

> If strategic bombing on an extensive scale is to be continued during the coming winter without prohibitive losses, a considerable increase in bomber protective measures will be a *sine qua non*, since it must be assumed that the enemy night fighter organisation will be even stronger and more efficient than it was last year.[43]

Addison issued this memo just over month before the publication of a new directive outlining the strategic air campaign's mission, the first since 17 April, which continued to stress the overriding priority of 'the progressive destruction and dislocation of the German military, industrial and economic system', in addition to the 'direct support of land and naval forces'. Specifically, the directive stipulated that 'Counter Air Force Action' which had witnessed OCA efforts of the type discussed above, would no longer be a priority for the strategic air campaign as the *Luftwaffe's* 'fighting effectiveness has now been substantially reduced', adding that 'we are no longer justified in regarding the (*Luftwaffe*) and its supporting industries as a primary objective for attack'. Instead, 'policing actions against the (*Luftwaffe*) are to be adjusted … No fixed priority is, therefore, assigned to policing attacks against the (*Luftwaffe*). The intensity of such attacks will be regulated by the tactical situation existing'. Beyond the adjustment to the strategic air campaign's OCA effort, it was to continue the provision of direct support for land and naval operations; attacks against industrial areas as and when required and when tactical and meteorological conditions permitted; supporting the covert and clandestine work of the Special Operations Executive [SOE]; attacks in support of

[43] 'Fighter Support for Bomber Command During the Coming Winter, Memo from Air Cdre Addison, AOC-in-C, 100 Group to Headquarters Bomber Command, 2 August 1944', AIR 14/735.

the Russian Army and attacks of so-called ‘fleeting targets’ such as key *Kriegsmarine* surface combatants in port. The requirements for attacks against industrial areas as outlined in the 14 September directive was further clarified in a 25 September directive which stressed that the first priority, as regards such efforts, was to be the German oil industry ‘with special emphasis on petrol … including storage’. Second priority targets included German rail and canal transportation, automotive production and storage facilities, and ordnance depots.[44] This directive underscored the reduction in focus on OCA enshrined in the 14 September directive, and mirrored the requirements regarding direct land and naval support, and SOE operations.

Although these directives downplayed the need for OCA, the success of OCA efforts such as Butterscotch against *Luftwaffe* fighter strength was short-lived. Damage at six of the airfields attacked during Buttersctch was repaired, and a second OCA effort against *Luftwaffe* fighter strength was mounted in September against six fighter bases in the Netherlands, with 670 Bomber Command aircraft hitting these targets on 3 September and rendering them unusable; although this time employing aircraft exclusively from the RAF. These initiatives continued with similar OCA attacks performed against four *Luftwaffe* fighter airfields in the Netherlands and Germany on 17 September. On this occasion, as well as contributing to the general degradation of *Luftwaffe* fighter strength, these OCA efforts were aimed at destroying potential fighter opposition to the airborne element of Operation Market Garden; the Allied attempt to outflank the northern end of the Siegfried Line of defensive fortifications stretching

[44] ‘14 September 1944. To Deputy Chief of the Air Staff, Air Marshal Sir Norman Bottomley, and to Commanding General, United States Strategic Air Forces in Europe, General Carl Spaatz, from Chief of the Air Staff, Marshal of the Royal Air Force, Sir Charles Portal, and Commanding General, United States Army Air Forces, General HH Arnold’, in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.171-172.

from Kleve on the German-Dutch border, to Germany's border with Switzerland. The effect of the attacks on 17 September was to render the targeted airfields unusable.[45]

During the same month that Butterscotch was mounted (September 1944), the Carpet-III ECM commenced installation on the aircraft of 100 Group's 214 and 223 Squadrons, with 171 and 199 Squadrons following towards the end of the year.[46] The Carpet-III ECM was designed to jam FuMG-65 FC/GCI radars.[47] While 100 Group's aircraft were outfitted with Carpet-II, a version of the ECM, called Carpet-III, was developed to outfit individual Main Force aircraft to protect them against the FuMG-65 and the AAA for which they provided fire control.[48] Like the original Carpet ECM, deployed with the Command from April 1944, the new variants of the countermeasure applied SEAD at the Localised level to provide protection for individual aircraft during their missions in the vicinity of hostile radar, and applied the Stealth/Surprise approach, intended as it was to reduce the useful range of hostile FC/GCI radars.[49]

In tandem with the jamming of ground-based air surveillance and FC/GCI radar, Bomber Command concerned itself with jamming *Luftwaffe* AI radar, particularly the FuMG-220.[50] While several variants of Window were developed to jam this AI radar, it was clear to the Command by September 1944 that additional ECMs should be employed to ensure as full a coverage of the FuMG-220's waveband as possible.[51] The introduction of Window optimised

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[45] AIR 41/56, pp.101-102.
[46] '100 Group Fortnightly Progress Report No.20', AIR 14/2348.
[47] 'Future Employment of 214 and 223 Squadrons, Memo AVM Addison, Headquarters 100 Group to Headquarters, Bomber Command 8 September 1944', AIR 14/736.
[48] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944', AIR 20/8071.
[49] Dougherty, *Defense Suppression,* pp.26-27.
[50] AIR 41/56, p.78.
[51] 'Countermeasures Against SN.2, AVM Addison, Memo from Headquarters, No.100 Group to Headquarters, Bomber Command, 16 September 1944', AIR 14/736.

to jam AI radar resulted in development of the Airborne Grocer [ABG] ECM proposed for use by 100 Group's Fortress-BII/III aircraft of 214 Squadron. Yet this ECM never saw operational service, as the FuG-202 *Lichtenstein*-BC UHF AI radar, which the ECM was intended to jam, was thought to have left *Luftwaffe* service by July 1944.[52] As this ECM never was never deployed, it is not possible to state the SEAD level at which it was employed, or its method of application. In tandem with the use of Window to jam *Luftwaffe* AI radar, Addison proposed employing the American Dina ECM, itself developed from an American version of Mandrel, with the British version of Dina, converted to jam the FuMG-220 radar and codenamed Piperack.[53]

The concept of operations envisaged by Addison for Piperack was to outfit a special force of aircraft with the ECM, in a similar fashion to 100 Group's approach with Mandrel after it had been removed from the Main Force. Addison believed that it would be more productive to deploy Piperack across one or two dedicated squadrons as this would reduce the maintenance burden as opposed to having the ECM deployed on all, or a large number, of Main Force aircraft. Secondly, it avoided Main Force aircrew being tasked with operating the ECM on top of their additional duties, and would mean that specialist Piperack aircraft could be operated away from the Main Force if necessary to assist spoofing missions. At the time of writing in mid-September 1944, Addison envisaged the ECM being added to the Fortress-BII/III aircraft of 214 and 223 Squadrons.[54] In SEAD terms, Piperack provided Localised level suppression as it was intended to protect aircraft in its *locale* for the duration of their missions. Localised

[52] 'Airborne Grocer: Operational Use, Memo from AVM Walmsley to HQ 100 Group, 29 June 1944', AIR 14/737, No 100 SD (Special Duties) Group Fortress: radio countermeasures Squadron organisation and Grehan, Mace, *Bomber Harris*, p.289.
[53] 'Countermeasures Against SN.2, AVM Addison, Memo from Headquarters, No.100 Group to Headquarters, Bomber Command, 16 September 1944', AIR 14/736.
[54] *Ibid.*

level SEAD was applied, in the case of Piperack, through the application of Mass as the ECM was intended to jam *Luftwaffe* AI radar in its entirety across wavebands of 69MHz to 93MHz, and 95MHz to 210MHz in the vicinity of the Main Force.[55]

Beyond its efforts jamming *Luftwaffe* radar, 100 Group was focused on jamming radio communications. Relevant ground countermeasures introduced during this period included the Jostle-IV ECM in the airborne domain, the characteristics of which are discussed in the previous chapter. Prior to the introduction of this ECM the dominant airborne countermeasure designed to jam *Luftwaffe* radio communications was ABC used to jam *Luftwaffe* VHF R/T communications employed for the ground control of fighters.[56] ABC was installed onboard the Lancaster-BI/III heavy bombers of the Command's 101 Squadron. In September, Addison urged that 101 Squadron end its ABC role, arguing that this mission should be absorbed by 100 Group. In a memorandum sent to Bomber Command headquarters on 8 September, he posited that it was inconvenient to have one Bomber Command group, in this case 1 Group, equipped with a radio communications jamming squadron to support that Group's operations, when other Main Force Groups maybe performing separate operations simultaneously and thus bereft of such jamming. Addison stated that it made more practical sense to have ABC jamming consolidated in 100 Group, as this was a specialist ECM organisation, with the countermeasure to be used by 214 and 223 Squadrons. Ultimately he suggested that removing ABC jamming from 101 Squadron's remit would allow it '(to) revert to a full-time bombing role'.[57] In October 1944 Bomber Command took the decision that 101 Squadron was no longer required to perform ABC jamming, with 100 Group picking up the baton of ABC

[55] Streetly, *Confound and Destroy*, p.160.
[56] 'Glossary of Codenames and Other Terms used in conjunction with RCM', AIR 20/1568.
[57] 'Future Employment of 214 and 223 Squadrons, Memo AVM Addison, Headquarters 100 Group to Headquarters, Bomber Command 8 September 1944', AIR 14/736.

jamming in its entirety, deploying the ECM onboard the Fortress-BII/III aircraft of 214 Squadron.[58]

The Jostle-IV ECM was initially deployed onboard the Fortress-BII/III aircraft 214 Squadron, being used for the first time in July, with these aircraft accompanying the Main Force. A useful by-product of the Jostle-IV ECM was that it caused interference to the FuMG-220 AI radar.[59] The efficiency that this ECM exhibited led to Addison requesting in September 1944 for its installation on the Liberator-BVI aircraft of 223 Squadron.[60] As noted in the previous chapter, the countermeasure was designed to protect Main Force aircraft during their mission in their *locale*, hence conforming to the practice of SEAD at the Localised level. It was also used to perform the Mass jamming of *Luftwaffe* radio communications, operating as it did across HF and VHF communications.

October - November 1944: 100 Group's Heavy Units Gain Additional Strength

By November 1944, Addison's intention to have Piperack deployed onboard 214 and 223 Squadron's aircraft was a reality, with the Group's dedicated ELINT gathering unit, 192 Squadron, also deploying the ECM to analyse its effect on AI radar. Following its service entry in October 1944, and a number of modifications to take account of changing *Luftwaffe* FuMG-220 transmission frequencies, the definitive version of Piperack entered service with 214 Squadron. Aircraft carrying the ECM would jam AI radar in the *locale* of the Main Force's target, this denying fighters information as to the location of the bombers in the Main

[58] 'Letter from AVM Addison, AOC-in-C 100 Group to AVM HSP Walmsley, SASO, HQ Bomber Command, 11 October 1944', AIR 14/2658, No.100 Group: Extracts from AOC's files, December 1943 to May 1945.
[59] AIR 41, p.78, p.157.
[60] 'Future Employment of 214 and 223 Squadrons, Memo AVM Addison, Headquarters 100 Group to Headquarters, Bomber Command 8 September 1944', AIR 14/736.

Force; this was a particularly useful capability when bad weather seriously degraded the visual detection of the Main Force increasing the reliance of *Luftwaffe* aircrew on their AI radar.[61]

Figure XIII - 100 Group Order of Battle: June - November 1944

Squadron	Base	Aircraft	Role
192	RAF Foulsham	Mosquito-BIV/BXVI Wellington-BIII Halifax-V Mosquito-II	ELINT gathering
141	RAF West Raynham	Beaufighter-VI Mosquito-II/VI/XXX	Fighter
239	RAF West Raynham	Mosquito-II/VI/XXX	Fighter
515	RAF Little Snoring	Mosquito-II/VI	Fighter
169	RAF Little Snoring	Mosquito-II/VI/XIX	Fighter
214	RAF Sculthorpe/RAF Little Oulton	Fortress-BII/III	Electronic Warfare
199	RAF North Creake	Stirling-BIII	Electronic Warfare
803	RAF Cheddington	B-17F/G	Electronic Warfare
157	RAF Swannington	Mosquito-XIX/XXX	Fighter
85	RAF Swannington	Mosquito-XII/XVII	Fighter
23	RAF Little Snoring	Mosquito-VI	Fighter
223	RAF Oulton	Liberator-VI/Fortress-BII/III	Electronic Warfare
171	RAF North Creake	Stirling-BII/Halifax-BIII	Electronic Warfare

Source - Bowman, Cushing, *Confounding the Reich*, pp.235-255.

[61] AIR 41, pp.157-158.

Alongside Addison's concerns regarding the potential growth in *Luftwaffe* fighter strength, he expressed misgivings regarding the ability of the TRE to remain abreast of technological developments which could be applied to the *Luftwaffe* IADS:

> (A)ccording to an opinion expressed by TRE at a recent meeting at Air Ministry, it would seem that our scientists can no longer keep pace with developments in the German defensive system, and so are unable to provide technical countermeasures capable of keeping our losses within reasonable limits.[62]

Addison proposed two approaches to meet the challenge of intensified fighter opposition: The first was to increase the fighter strength at 100 Group's disposal from five squadrons to nine.[63] The second was to increase the quantity and capability of the dedicated jamming aircraft which the Group had at its disposal. At the start of the period under examination, 100 Group had four 'heavy' squadrons available to perform radio and radar jamming. These units; 199 Squadron, 214 Squadron and 223 Squadron, plus 803 Squadron, seconded from the USAAF, employed a range of aircraft including the Stirling-BIII equipped with Mandrel and capable of dispersing Window furnishing 199 Squadron between July 1943 and March 1944 and the Halifax-BIII, also equipped with Mandrel and able to disperse the Window ECM, equipping 199 Squadron from February 1945 until the end of the war. 100 Group was also equipped with the Fortress-BII/III carrying the Piperack, Carpet, Jostle-IV and Window ECMs. 803 Squadron would, meanwhile, operate B-17F/Gs between January and September 1944 and Consolidated B-24H/J Liberator heavy bombers converted for the EW role from June 1944.

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[62] 'Fighter Support for Bomber Command During the Coming Winter, Memo from Air Cdre Addison, AOC-in-C, 100 Group to Headquarters Bomber Command, 2 August 1944', AIR 14/735.
[63] *Ibid.*

To increase the number of heavy aircraft available, Addison proposed that the Group raise two additional heavy squadrons to support EW tasks, and to expand 100 Group's 199 and 214 Squadrons.[64] Addison's requests would be fulfilled via the establishment of 171 Squadron which contained, from September to November 1944, Stirling-BIIIs carrying Mandrel and dispersing Window, and from October 1944 to January 1945 Halifax-BIIIs also carrying Mandrel and dispersing Window.[65] Additionally 100 Group received a second new unit in the form of 223 Squadron. Joining the Group in August 1944 this squadron was equipped with Liberator-BVI aircraft equipped with the Piperack, Carpet, Jostle-IV and Window ECMs and six Fortress-BII/IIIs equipped with the same ECMs as the Liberator-BVIs joined the squadron in April 1945. With new aircraft equipping 100 Group, Addison was able to further define its mission. Writing in early November, he summed up the roles of the Group's 'heavy' aircraft:

> (i) Depriving the enemy of early warning of the approach of our bomber formation.
> (ii) Interfering with the enemy fighter control by jamming Radar and R/T and W/T control channels.
> (iii) Supplying 'spoof' raids to divert the enemy's fighter forces – or to subject them to attrition by causing them to be altered unnecessarily.[66]

Ultimately, Addison's request and granting of additional heavy aircraft in anticipation of enhanced *Luftwaffe* air defences was a clear example of a proactive Bomber Command EW policy, and was prescient: Bomber Command would be highly reliant on the airborne ECMs which the Group could supply to the Main Force between May and November 1944. As previous chapters have noted the Command had, until the Normandy Breakout, used radar and radio communications/navigation systems jamming performed by 80 Wing, responsible for

[64] 'Memo from AVM Addison, 8 August 1944', AIR 14/736.
[65] AIR 41, p.202.
[66] 'AVM Addison, Brief Survey of the Operational Functions of No.100 Group, 4 November 1944', AIR 14/2657.

the employment of ground-based ECMs, which became a constituent part of 100 Group following the latter's formation in November 1943. The changing situation on the ground had implications for 80 Wing as much as it did for the rest of Bomber Command. Harris had observed that Germany's loss of territory following the liberation of France and Belgium had deprived the *Luftwaffe* of ground where it could deploy radar as well as fighter defences to be able to detect and intercept Bomber Command aircraft at range. He asserted that: 'No other single occurrence in the whole war was responsible for such a great reduction in bomber casualties.'[67]

Following the liberation of France, proposals were made by the Group's headquarters to move 80 Wing's ECM activities to the continent. The Wing's ECMs would be converted to operate in a mobile fashion and were to be moved close to the Franco-German border to provide enhanced jamming against *Luftwaffe* radar and radio communications/navigation systems. Eventually, 80 Wing would deploy to the continent with a single mobile headquarters, six VHF communications jamming ECMs and eight Ground Mandrel radar jamming units.[68] Between May and November 1944 several of 80 Wing's ground ECMs had become obsolete owing to technical developments within the *Luftwaffe* IADS. For example, as of early autumn 1944, Ground Grocer was no longer useful due to changes in the transmission frequencies of *Luftwaffe* AI radar which the ECM could no longer jam. Similarly Ground Cigar, which was designed to jam *Luftwaffe* VHF R/T communications across the Pas de Calais and towards the Dutch coast, was becoming obsolete as *Luftwaffe* fighter sorties into these areas were increasingly rare following the latter's loss of bases in France.[69] Likewise for the Special

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[67] Grehan, Mace, *Bomber Harris*, p.289.
[68] AIR 41, pp.206-207.
[69] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944, page 5', AIR 20/8071.

Tinsel ECM, which used a receiver based at Kingsdown in Kent to monitor *Luftwaffe* HF fighter control R/T and to then notify Bomber Command aircraft equipped with Tinsel of the R/T frequencies for jamming, was no longer applicable.[70] During the period under examination, the *Luftwaffe* increasingly used HF Morse code W/T as opposed to R/T rendering Special Tinsel obsolete.[71]

The necessity of moving 80 Wing's operations to the continent was dictated by geography: As the Wing's jamming operations were performed from the ground, the range of the RF jamming which it was able to perform was limited by line-of-sight, although this range could be extended by using towers to mount jammers. For example, when a Ground Mandrel ECM was located 100ft (30.4m) above sea level, its RF jamming power would be sufficient to reduce the detection range of a FuMG-80 radar positioned 34.7nm (64.3km) from the jammer to 37.4nm, as opposed to the 107.9nm (200km) range that the radar would usually have.[72] For this reason, many of 80 Wing's Ground Mandrel jammers had been located along the south coast of England to jam ground-based air surveillance radars along the French coast; the logic being to reduce the *Luftwaffe's* early warning time for Bomber Command aircraft approaching France. With France liberated, there were no *Luftwaffe* radars on the French coast left to jam, thus the necessity of moving 80 Wing's operations to the continent to ensure that these ECMs remained within jamming range of existing radar threats.[73]

[70] 'Glossary of Codenames and Other Terms used in conjunction with RCM', AIR 20/1568.
[71] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944, page 5', AIR 20/8071.
[72] 'Glossary of Codenames and Other Terms used in conjunction with RCM', AIR 20/1568.
[73] 'RCM in Support of Bomber Command, Memo from AVM Cadell, DG of S to DCAS, 9 November 1944', AIR 20/8071.

The concept of operations envisaged for 80 Wing was to position its radio and radar ECMs on high ground across an area stretching between Eindhoven in the southern Netherlands (liberated in September 1944) and the Franco-Swiss border. Shorter range jamming would continue to be performed by 100 Group's heavy aircraft in support of the Main Force. The redeployment of 80 Wing would have another important effect: The lengthening of the autumnal and winter nights in late 1944 would allow Bomber Command to perform increasingly long sorties into Germany and use the cloak of darkness for protection from *Luftwaffe* fighters. Having the Wing's ECMs positioned closer to Germany would provide jamming support to the Main Force when it performed such endeavours.[74] 80 Wing planned to deploy its ECMs at intervals of between 60 miles (96km) and 100 miles (160.9km) from Eindhoven, in the southern Netherlands to the Franco-Swiss border. Meanwhile radar jamming ECMs would be positioned every 20 miles (32km) to 30 miles (48.2km) along the same axis, with the Wing's jamming efforts commencing on 18 February 1945.[75] However, as the discussion below will highlight, the operational situation on the ground would have implications for 80 Wing's deployment and stymie their ability to perform such jamming. The urgency of the deployment of 80 Wing's ground-based ECMs was emphasised in a signal sent from the Air Ministry to SHAEF on 13 November:

> Bomber Command urgently require to have set up a system of ground RCM stations in the forward areas in France to interfere with the enemy night defences. This would help considerably in keeping our bomber losses down and would increase the scope of bomber approach tactics.[76]

As this discussion illustrates, although the request was made in mid-November it was not until mid-February 1945 when 80 Wing's ECM efforts commenced. The delay in the arrival

[74] *Ibid.*
[75] AIR 41, p.208.
[76] 'Signal from Air Ministry to SHAEF, 13 November 1944', AIR 20/8071.

of 80 Wing's headquarters on the continent on 4 December 1944, and its commencement of operations two months later, was the result of the German Army's Ardennes Counteroffensive (popularly referred to as the 'Battle of the Bulge') which threatened the city of Verviers in eastern Belgium where the Wing's headquarters was to be located.[77] The deployment of 80 Wing's ground ECM capability to the continent was a clear reaction to the threat that *Luftwaffe* radar and radio communications continued to pose to Main Force operations.

Conclusions

The penultimate six months of Bomber Command's EW efforts are examined by the existing literature. This focused on the use of specific aircraft, and the implementation of the Mandrel Screen and SWF to protect the Command's aircraft, alongside the introduction of new ECMs such as Jostle-IV, Carpet and Piperack. Other events such as the arrival of the Ju-88 and its AI radar in the UK are examined, plus the impact that Germany's progressive loss of territory had on the *Luftwaffe* IADS. Nonetheless the literature makes few references to decisions by the Command's leadership regarding its long-term intentions *vis-à-vis* the IADS. Several of the existing works focused on the exploits of individual air and ground crews whom supported the Command's EW efforts with a strong emphasis on 100 Group's kinetic air-to-air endeavours. Crucial omissions include any discussion of the importance of Overlord in providing the Command with a template it could use to degrade the IADS for the remainder of the war.

Between May and November 1944, Bomber Command continued to face aircraft losses in the wake of Overlord. The continued focus on targets in Germany by the strategic air campaign

[77] AIR 41, p.234.

resulted in the *Luftwaffe* IADS remaining a threat. Reactive policies, such as the adoption of the Mandrel Screen and the SWF were used in an attempt to reduce losses. The activation of the Mandrel Screen and SWF saw the Command performing both Campaign and Localised SEAD, given that this was intended to continually wear down the IADS, as much as it was to protect Main Force aircraft. This Campaign and Localised SEAD was applied using Manoeuvrist and Stealth/Surprise approaches in the case of the Mandrel Screen, and employing the Manoeuvrist approach in the case of the SWF. Meanwhile, new ECMs introduced during this period such as the latest incarnation of Carpet were the product of reactive EW policies regarding the continued threat posed by *Luftwaffe* FC/GCI radar and were deployed at the Localised level and applied using the Stealth/Surprise approach. Similarly, the advent of the Piperack ECM was a response to the continued threat posed by *Luftwaffe* AI radar and was used for Localised SEAD by applying Mass. Nevertheless, Addison's request for additional heavy jamming aircraft represented an example of proactive EW policy as it was made in anticipation of continued technological developments *vis-à-vis* the IADS. Ultimately, at this point in the war Bomber Command was pursuing both proactive and reactive EW policies which were applied at the Campaign and Localised levels using the Manoeuvrist, Mass and Stealth/Surprise approaches.

If Operation Overlord had been a dress rehearsal for the implementation of the Mandrel Screen and the SWF, then the second six months of 100 Group's existence had shown that the organisation had finally reached its full strength in terms of the ECMs it could bring to bear against the IADS. The stage was now set for 100 Group to assist in providing the *coup de grace* to the *Luftwaffe* IADS. Writing in October 1944 and looking forward to 1945, Addison reflected on the successes enjoyed by the Group to date, observing that: 'We have got the Hun rattled and it is up to everyone who has a hand in radio countermeasures to do his utmost to ensure that he stays that way.'[78]

[78] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944', AIR 20/8071.

CHAPTER EIGHT

BOMBER COMMAND ELECTRONIC WARFARE POLICY AND SUBSEQUENT SUPPRESSION OF ENEMY AIR DEFENCE POSTURE: NOVEMBER 1944 TO MAY 1945

Introduction

The final chapter of this thesis will examine Bomber Command's EW policy and subsequent SEAD posture from November 1944 until May 1945. It will commence by detailing the priorities of the strategic air campaign during the final six months of the war, chiefly the destruction of the German oil industry and transportation system, and the controversy that this prioritisation engendered *vis-à-vis* Bomber Command's leadership. The chapter will note that Command losses remained comparatively low during this period despite loss increases experience in late 1944/early 1945. These comparatively low losses were the result of the *Luftwaffe* experiencing fuel shortages and the loss of territory on which to locate radar as the Allied armies drove further into Western Europe. Loss rates were also kept low, the chapter will continue, by Bomber Command's continuing EW efforts, and a lack of new radar and radio communications/navigation systems entering service with the *Luftwaffe's* IADS. The chapter will continue that the use of the Mandrel and Window ECMs against *Luftwaffe* ground-based air surveillance radar was particularly important in the final months of the war to increasingly wear down the effectiveness of the IADS. At the same time, Bomber Command was greatly concerned regarding potential advances in German AI radar technology which could risked rendering some of its ECMs useless. The priorities of the strategic air campaign would change slightly in January 1945 with a renewed emphasis placed upon the destruction of the *Luftwaffe*, and in particular its new jet fighters which, fortunately for Bomber Command, would appear too late in the war to seriously challenge Allied air superiority. The chapter will add that ground-based jamming of the IADS would commence in February 1945, while Bomber Command losses during night operations would increase in March. This resulted in the Command's leadership encouraging an expanded use of feint operations to continually confuse the IADS. Finally, the last major expression of policy as regards the strategic air campaign occurred in April, which was directed towards assisting the Allies' ground advance through Germany.

November 1944 - May 1945: The Strategic Air Campaign

On 18 October, Bomber Command and the USSTAF agreed to establish a Combined Strategic Targets Committee [CSTC] with the intention of developing an agreed plan for the continuation of the strategic air campaign. AM Arthur Tedder, the SHAEF deputy supreme commander recommended concentrating the strategic air campaign against German rail and oil targets.[1] A further meeting held at SHAEF headquarters on 28 October resulted in the publication of a new directive on 1 November stipulating the priorities of the strategic air campaign. The directive's initial wording was largely unchanged from previous directives, stressing the 'progressive destruction and dislocation of the German military, industrial and economic systems and the direct support of land and naval forces'. The directive divided targets into two priorities; the German oil industry, including storage facilities and German

[1] Overy, *The Bombing War*, p.387.

transportation targets, particularly those in the Ruhr.[2] This prioritisation of transportation targets was to aid the Allied ground advance in Western Europe which, by November 1944, had resulted in the liberation of significant quantities of Belgian, and the vast majority of French, territory plus Luxembourg and the southern Netherlands. Indirectly it was also hoped that the strategic air campaign would aid the Allied advance through Italy and the Red Army's advance on the Eastern Front. To this end, the CSTC recommended that attacks be directed against German rail targets within an area spanning from the Rhine River eastwards to a line running roughly north to south from Hamburg in northern Germany, through Hanover and Würzburg, and ending at Ulm in the south. In the east of Germany, rail targets in the vicinity of Leipzig and Magdeburg were also prioritised by the CSTC. Additional targets including 'important industrial areas' when the weather and tactical situation permitted, with a view to causing the maximum destruction of German oil and transportation targets therein, were stipulated by the directive. Finally, as with previous directives issued in 1944, the strategic air campaign was to directly assist land and naval operations, and the clandestine efforts of the SOE when required. Finally, the 1 November directive downgraded the *Luftwaffe* as a target writ large, stating that 'its fighting effectiveness has been substantially reduced' as a result of earlier attacks on aircraft production and maintenance facilities, and as the result of previous OCA efforts. The directive added that: 'In these circumstances, we are no longer justified in regarding the German Air Force and its supporting industry as a primary objective for attack.' Efforts against the *Luftwaffe*, the directive continued, were to be restricted to 'air policing attacks' as and when the tactical situation required.[3]

[2] '1 November 1944. Directive No.2 for the Strategic Air Forces in Europe', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.178.
[3] AIR 41/56, p.157, pp.178-179.

The 1 November directive was followed with a letter from Bottomley to Harris regarding the latter's targeting priorities. Overy argued that Harris was mistrustful of attacks against oil and communications targets, referred to by the AOC-in-C as 'panacea' targets, at the expense of attacks against large urban areas.[4] Bottomley's letter stressed that 'the maximum effort is to be made to maintain and, if possible, intensify pressure on (the oil) target system'. Bottomley continued that, alongside the priorities against oil targets, 'the maximum possible disorganisation of the enemy's transportation system should be created, particularly in the Ruhr area'. Reflecting his animosity towards such targets, Harris annotated Bottomley's letter with the comment 'Here we go 'round the Mulberry Bush'.[5] As Overy stated, Harris 'remained wedded to the idea that oil and transport were expensive, dangerous and futile objectives when the destruction of cities could be more easily accomplished'.[6] Davis-Biddle continued that Harris raised objections to the target sets outlined by Bottomley and the 1 November directive by stating that the weather could intervene in the ability to hit these targets.[7]

Figure XIV – Bomber Command Losses for Sorties Despatched: December 1944 - May 1945

Month/Year	Night/Day Operation	Sorties Despatched	Total Losses	Total losses as a percentage of sorties despatched
Dec-44	Night	11239	88	0.8%
	Day	3656	31	0.8%
	Total	**14895**	**119**	**0.8%**
Jan-45	Night	9603	121	0.3%
	Day	1304	12	0.9%
	Total	**10907**	**133**	**1.2%**

[4] Overy, *The Bombing War*, p.387.
[5] '1 November 1944. Air Marshal Sir Norman Bottomley (Deputy Chief of the Air Staff) to Air Chief Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.177.
[6] Overy, *The Bombing War*, p.387.
[7] Davis-Biddle, *Rhetoric and Reality in Air Warfare*, p.247.

Feb-45	Night	13715	164	1.2%
	Day	3685	9	0.2%
	Total	**17400**	**173**	**1.0%**
Mar-45	Night	11585	168	1.5%
	Day	9606	47	0.5%
	Total	**21191**	**215**	**1.0%**
Apr-45	Night	8822	31	0.4%
	Day	5001	22	0.4%
	Total	**13823**	**53**	**0.4%**
May-45	Night	349	3	0.9%
	Day	1068	0	0.0%
	Total	**1417**	**3**	**0.9%**

Source - 'Appendix 10'in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.431-436.

Throughout the period under examination Command aircraft losses as a percentage of sorties despatched remained low, averaging 0.9 percent for the final six months of the war, despite slight increases experienced in late 1944/early 1945. The official record of the *RAF Bombing Offensive against Germany* attributes these low losses to the provision of fighter escorts to accompany Bomber Command aircraft, and the lack of success experienced by the *Luftwaffe* in performing day interceptions of Command aircraft. The publication continued that serious and minor damage inflicted by AAA was a cause for concern, but that cloud cover during December and January over Germany helped to reduce the effectiveness of AAA against Bomber Command's aircraft.[8] Overy added that the IADS' reduction in effectiveness was also the result of the *Luftwaffe's* deteriorating fuel situation. He stated that *Luftwaffe* fighter aircrew training was degraded by fuel shortages resulting in the force being unable to provide a full training programme. He stated that the Siemens FuG-218 *Neptun* AI radars equipping some of the *Luftwaffe* fighters required the aircraft to be powered either by its own engines, or by an external generator, which was often not done to conserve fuel, hence depriving aircrew of adequate training on this vital equipment for locating aircraft. Moreover, *Luftwaffe* ground-

[8] AIR 41/56, p.167.

based air surveillance and FC/GCI radar stations fell victim to fuel shortages, which meant that they remained unserviceable at times, which further deprived fighter aircrew of the opportunity to train with these radars, degrading fighter and FC/GCI radar coordination proficiency. At the general level fuel shortages were affecting both training flights, and the length of time fighters were permitted to be airborne during combat air patrols.[9] Despite his misgivings regarding the targeting of German oil production and storage as part of the strategic air campaign in November, Harris later argued in 1947 that hitting such targets had a fortuitous outcome as regards *Luftwaffe* fighter operations: 'The offensive against oil naturally brought about a vicious circle and for the lack of oil the enemy's fighters were often unable to defend the oil plants.' Alongside the fuel situation Harris argued that the changing situation on the ground as the Allies advanced through Western Europe was having an appreciable effect on *Luftwaffe* ground-based air surveillance and FC/GCI radar coverage: 'The most serious blow to the enemy was the loss of his early warning (radar) stations on the Channel coast; the only stations he now had were on the German frontier, or on the coast of Holland.' Harris continued that this resulted in the *Luftwaffe* having less than one hour's warning of any incoming aircraft, with the *Luftwaffe* fighter force needing 40 minutes' warning time at the least if it was to mount an effective defence against any attack.[10]

The *Luftwaffe's* loss of radar coverage, and the fuel situation was compounded by Bomber Command's EW endeavours, and the lack of any new radar or radio communications/navigation systems entering service with the IADS in the closing stages of the war. Grehan and Mace observed that no new equipment was introduced to this end which freed Bomber Command from having to devise new tactics, techniques and procedures, or

[9] Overy, *The Bombing War*, p.387, p.405.
[10] Harris, *Bomber Offensive*, p.192, p.202.

new ECMs for jamming. To further complicate matters, the authors argued, the radar and radio communications/navigation systems upon which the *Luftwaffe* relied were now being jammed in their entirety by the Command, with the official history of Bomber Command's strategic air campaign claiming that the employment of ECMs was instrumental in keeping Bomber Command loss rates low.[11]

During the final six months of the war 100 Group remained at the centre of the Command's efforts to wage EW against the IADS. It applied ECMs as part of the Command's SEAD effort and despatched a total of 8,356 sorties during the day and night to support Bomber Command operations through the application of ECMs, the collection of ELINT, mounting fighter escorts and performing OCA. The Group performed operations regardless of whether or not the Command was mounting a major attack.[12] As witnessed during the previous six months these efforts exemplified Campaign level SEAD. Although outside the timeframe of this chapter, on 17 April 1944 Addison had written to Dalton-Morris stating that the intention of 100 Group was to perform: 'the wearing down of the Huns by coaxing (their fighters) to fly on as large a scale as possible even on nights when the 'heavies' (Main Force aircraft) are not operating'. With this comment, Addison had 'set out his stall' regarding his long-term vision for 100 Group and was thus confident of the overall contribution that it would make to Bomber Command operations. The sheer volume of operations performed by 100 Group during the period under discussion is testament to Addison's intention to 'wear down the Huns' and thus create such favourable conditions for the Command's operations. 100 Group performed operations on over 70 percent of occasions when Bomber Command was undertaking operations of any description, and the Group's efforts continued regardless of

[11] Grehan, Mace, *Bomber Harris*, p.298.and AIR 41/56, pp.167-168.
[12] AIR 41/56, pp.167-168.

whether or not the Command was performing a large-scale area attack against a specific target as even on nights the Main Force was not operating, 100 Group would mount operations to continue to attrit the IADS.[13] Moreover, the use of 192 Squadron to collect ELINT illustrated that 100 Group and the Command in general, were serious about gathering as much intelligence on the behaviour of the electronic elements of the IADS as possible to continually hone the EW tactics, techniques and procedures that it was applying against the IADS. This was marked contrast from the early stages of the war, where the Command had been largely disinterested in ECMs, and ELINT collection was primarily restricted to the work of Jones and his colleagues.

Figure XV - 100 Group Order of Battle: November 1944 – May 1945

Squadron	Base	Aircraft	Role
192	RAF Foulsham	Mosquito-BIV/BXVI Wellington-BIII Halifax-V Mosquito-II	ELINT gathering
141	RAF West Raynham	Beaufighter-VI Mosquito-II/VI/XXX	Fighter
239	RAF West Raynham	Mosquito-II/VI/XXX	Fighter
515	RAF Little Snoring	Mosquito-II/VI	Fighter
169	RAF Little Snoring	Mosquito-II/VI/XIX	Fighter
214	RAF Sculthorpe/RAF Little Oulton	Fortress-BII/III	Electronic Warfare
199	RAF North Creake	Stirling-BIII	Electronic Warfare
803	RAF Cheddington	B-17F/G	Electronic Warfare
157	RAF Swannington	Mosquito-XIX/XXX	Fighter
85	RAF Swannington	Mosquito-	Fighter

13 'No.100 Group Operations Memorandum, Bomber Support Policy, May 1944', AIR 14/2657.

		XII/XVII	
23	RAF Little Snoring	Mosquito-VI	Fighter
223	RAF Oulton	Liberator-VI/Fortress-BII/III	Electronic Warfare
171	RAF North Creake	Stirling-BII/Halifax-BIII	Electronic Warfare
462	RAF Foulsham	Halifax-BIII	Electronic Warfare

Source - Bowman, Cushing, *Confounding the Reich*, pp.235-255.

The final enlargement of the Group's order of battle occurred in December 1944 with the addition of the Royal Australian Air Force's 462 Squadron located at RAF Foulsham in Norfolk. The Halifax-BIII aircraft flown by this squadron were tasked with employing the Window and Piperack ECMs against *Luftwaffe* AI and FC/GCI radar, and later would be tasked with deploying the ABC ECM against *Luftwaffe* radio communications, commencing its efforts in March 1945.[14] Given that the Second World War in Europe ended in early May, 462 Squadron only performed a few weeks of ABC jamming, far less than the 2477 ABC sorties 101 Squadron had performed since October 1943.[15]

During the last six months of the war, 100 Group was able to bring its full panoply of airborne ECMs to bear against the radars, both airborne and ground-based, supporting the *Luftwaffe* IADs. These included the Window ECM which was designed to jam the FuMG-62D FC/GCI and FuMG-80 ground-based air surveillance radars, and the force's FuG-202, Telefunken FuG-212 *Lichtenstein*-C1, Flugfunk Forschungsanstalt [FFO] FuG-216 *Neptun*, FFO FuG-217 *Neptun*, FFO FuG-218 *Neptun* and FuG-220 AI radars. This ECM was dispersed by the Fortress-BII/IIIs of 214 and 223 Squadrons, and the Liberator-BVIs of the latter unit, plus the Halifax-BIIIs of 171 and 462 Squadrons. Additional jamming directed against FuMG-62D

[14] AIR 14/2911 and AIR 41, p.138.
[15] AIR 41, p.138.

radars was provided by the Carpet-III ECM which operated across a band of 475MHz to 585MHz and was deployed by the Fortress-BII/IIIs of 214 Squadron, and the Fortress-BIIIs of 223 Squadron. Various versions of Mandrel were also used by 100 Group: These included the standard Mandrel ECM designed to jam FuMG-80, FuMG-*Freya Fahrstuhl*, FuMG-404, FuMo-51 and FuMG-402 ground-based air surveillance radars transmitting in wavebands of 68MHz to 78MHz, 88MHz to 142MHz, and 138MHz to 148MHz. Operating in its airborne configuration, Mandrel could reduce the detection range of the FuMG-80 radar from 155 nautical miles/nm (287 kilometres/km) to 34nm (63.7km). Mandrel outfitted the Stirling-BIIIs of 199 Squadron until March 1945, and the same aircraft of 171 Squadron, although these were phased-out of this squadron's service in December 1944. Mandrel did, however, remain deployed with the Halifax-BIIIs of 171 Squadron until the end of the war. Additional Bomber Command radar jamming was provided by the Mandrel-III ECM which was designed to jam ground-based air surveillance radars in the 148MHz to 196MHz waveband, notably the FuMG-80 and FuMG-402. This ECM was deployed onboard the Fortress-BII/IIIs of 214 Squadron, and the Stirling-BIIIs of 199 Squadron until March 1944. A third Mandrel variant, known as American Mandrel, transmitted in the 85MHz to 135MHz waveband and jammed the FuMG-80, FuMG-*Freya Fahrstuhl*, FuMG-404, FuMo-51 and FuMG-402 radars.[16] This ECM was deployed with the Stirling-BIIIs of 199 Squadron, until these were retired from service in March 1944.

In addition to these airborne ECMs Bomber Command continued its airborne efforts against the IADS radio communications. As of November 1944, the ABC ECM was operated by the Fortress-BII/IIIs of 214 Squadron. This ECM was designed to disrupt hostile radio

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[16] AIR 20/1568.

communications in the 36.3MHz to 42.3MHz, 30MHz to 33MHz and 48MHz to 52MHz wavebands and had a range of 43nm (80km). ABC was supplemented by the Jostle-IV ECM which jammed enemy HF and VHF communications. The Jostle-IV ECM had a range of between 8.6nm (15.9km) to 34.4nm (63.7km) and was deployed by the Fortress-BII/IIIs of 214 Squadron and 223 Squadron, plus the Liberator-BVIs operated by this latter unit.[17]

At this point in the war, Mandrel was particularly important in protecting Bomber Command aircraft as it was often deployed to generate a jamming screen behind which aircraft could be shielded as they approached their targets, or alternatively to create a deception in the minds of *Luftwaffe* fighter controllers regarding the target the Command intended to attack. The concept of operations for the MANDREL Screen was much as it had been during the previous six months, an example of Campaign level SEAD, reflected by Harris' assessment of the ECM's utility concerning the mounting of genuine and feint Bomber Command operations:

> The jamming was very effective, and it only remained for us to take every possible advantage of it when planning our attacks so that the enemy not only had too little time in which to get his … fighter force together, but would also find it impossible to decide, in the few moments he was given, which was the real attack and which were feints. We increased the number of feints, and also the number of real attacks, and the most complicated operations were repeatedly undertaken.[18]

Mandrel in this regard clearly contributed to the overall degradation of the IADS, while creating increasingly favourable conditions for Command operations. Thus it chimed with the Campaign-minded approach to SEAD which both Harris and Addison exhibited throughout their respective tenures.

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[17] *Ibid.*
[18] Harris, *Bomber Offensive*, p.202.

The Mandrel Screen was deployed alongside the SWF during the final six months of the war as described in the previous chapter. The Command could discern the effect that the Mandrel Screen/SWF combination was having on the FuMG-62D and FuMG-80 radars. As of December 1944, the *Luftwaffe* had attempted several modifications in the form of ECCMs which were added to its FuMG-65D FC/GCI radar, but these proved unable to neutralise the advantage which the Mandrel Screen/SWF combination afforded to Bomber Command. The effect which this ECM combination was having upon these radars was such that in December 1944 100 Group's ORS declared that the FuMG-62D and FuMG-65D were: 'no longer of fundamental importance to the (*Luftwaffe's*) night defence system'. The efficacy of the Group's jamming extended to the *Luftwaffe's* ground-based air surveillance radars notably its FuMG-402, FuMo-51 and FuMG-404 systems which had suffered a significant degradation in performance as a result of MANDREL Screen/SWF activity.[19] In the final six months of the war, Window was dispersed by 100 Group's SWF during almost every night when Bomber Command's aircraft were striking targets in support of the strategic air campaign. Window was effectively deployed regardless of whether a threat presented itself or not. Much like the application of the Mandrel Screen, the deployment of the SWF was an example of Campaign SEAD. Harris reflected that, alongside the other ECMs the Command was bringing to bear against the IADS, when teamed with feint Main Force operations 'aircraft dropping Window to simulate the arrival of a far larger force' were 'sometimes used to get the night fighter force into the air and so waste more aviation petrol, which was in particularly short supply'.[20] Thus, like the Mandrel Screen, the SWF was contributing to the long-term degradation of the *Luftwaffe* IADS. At the same time, both the Mandrel Screen and SWF exemplified the application of Localised level SEAD in that it was intended to also protect the Command's

[19] 'Enemy Night Defence ORS HQ No.100 (SD) Group, Note on Enemy Night Air Defence, Headquarters Bomber Command, 1 December 1944', AIR 14/3246.
[20] Harris, *Bomber Offensive*, p.192.

aircraft for the duration of their missions.[21] As had been the case between May and November 1944, the Mandrel Screen and SWF were applied using the Manoeuvrist and Stealth/Surprise approaches: The screen was used to reduce the detection range of ground-based air surveillance radar to minimise *Luftwaffe* fighter early warning time and hence conformed to the Manoeuvrist approach defined by Bellamy.[22] Similarly, this reduction of range caused by the Mandrel Screen resulted in the application of Dougherty's Stealth/Surprise SEAD method.[23] Moreover the SWF, which worked to deceive the *Luftwaffe* FC/GCI and AI radar as to the location of hostile aircraft, was also an example of Manoeuvrist SEAD via its employment of deception. Furthermore both the Mandrel Screen and the SWF were examples of proactive and reactive EW policies: Both ECMs were reactive as they were mounted in response to the losses which the IADS had hitherto shown itself capable of inflicting, yet they were also proactive as they were intended to prevent the IADS from regaining the initiative against Bomber Command.

Echoing Harris' arguments, the ORS report continued that the ground advance which, by late November 1944, had resulted in the liberation of most of Belgium, France and Luxembourg, had effectively deprived all of southern Germany of ground-based air surveillance radar coverage. The report added that this loss of territory in Western Europe had deprived the *Luftwaffe* of defence-in-depth, preventing its fighters from intercepting Bomber Command sorties before the Command's aircraft reached their targets in the Ruhr and southwest Germany. Despite these successes, the Group's ORS' observations sounded a note of caution and warned that the *Luftwaffe* might now seek radars outside the wavebands where the Mandrel Screen and SWF were effective, possibly in the region of 2.9 gigahertz [GHz]; so-

[21] Baltrusaitis, *Quest for The High Ground*, pp.26-27.
[22] Bellamy, C 'Manoeuvre Warfare', p.541.
[23] Dougherty, *Defense Suppression,* p.25.

called centimetric wave radars, with the ORS warning that Germany was accelerating its efforts in this domain.[24] Put simply, centimetric wave radar used higher frequency transmissions than had previously been employed by the *Luftwaffe*. Generally speaking the shorter the wavelength transmitted by a radar, the smaller the object the radar can detect. In air warfare terms, this means that a centimetric wave radar can discern a target, such as a bomber, in sharper detail than a radar transmitting at comparatively lower frequencies where the target might not be depicted in such detail. This would allow aircraft equipped with centimetric wave radars to see a target in greater detail, and to obtain a more accurate location of that target.

100 Group's ORS continued by sounding a pre-emptive note of caution concerning the *Luftwaffe's* use of AI radar: It advised in December 1944 that a new antennae structure was being developed for the *Luftwaffe's* FuG-217 AI radar and that the ORS expected this to operate in a waveband of 160MHz to 170MHz, however, should this come to fruition, the ORS expected that it could be jammed using Mandrel. It added that a frequency change to 500MHz for *Luftwaffe* AI radar would be futile as this could already be jammed by Window. As such, the ORS expected the *Luftwaffe* to configure the FuG-217 radar to transmit in the centimetric range, and cautioned that: 'it is reasonable to assume that a centimetric AI radar could appear before long.'[25] The proactive nature of the Command's EW policies can be seen from the concerns raised by the Group's ORS in December 1944 that, having experienced a significant degradation in the performance of its radars in the wake of its Mandrel Screen/SWF jamming efforts, the *Luftwaffe* might seek to develop and deploy centimetric wave radars. This posed the twin dangers of potentially providing radars which might be

[24] 'Enemy Night Defence ORS HQ No.100 (SD) Group, Note on Enemy Night Air Defence, Headquarters Bomber Command, 1 December 1944', AIR 14/3246.
[25] *Ibid.*

beyond the jamming bands of the current ECMs which the Group was deploying, while furnishing the *Luftwaffe* with radars which could give accurate location information as well as comparatively better target discrimination than the AI radars the *Luftwaffe* had used to date. Fortunately for Bomber Command, such fears would not materialise.

January 1945: The *Luftwaffe's* Resurgence

Following the November directive, a further directive was published by the Allied Combined Chiefs of Staff on 15 January. This continued to prioritise the first two targets of the November directive, namely oil and transportation, in addition to industrial and naval targets. The major change in the January directive compared to the previous directive was the renewed emphasis on OCA efforts. The November directive had downgraded the importance of these, while the new directive observed that the *Luftwaffe* had recovered; 'a great deal of its fighting strength' as demonstrated by the increase in losses for sorties despatched the Command suffered between December 1944 and January 1945. This, the January directive continued, was the result of the strategic air campaign's concentration on German oil and transportation targets, and of performing air attacks in support of Allied ground efforts in Western Europe. The focus of the strategic air campaign against these targets had allowed the *Luftwaffe* to concentrate on developing its fighter force, particularly: 'the rapid development of jet fighters,' which the directive warned, could be produced: 'on as large a scale as possible.'[26]

[26] '15 January, Directive No.3 for the Strategic Air Forces in Europe', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.181-182.

The *Luftwaffe* had commenced deploying such aircraft in the form of the Messerschmitt Me.262 in November. As such, the directive articulated that these aircraft are: ‘superior in speed and armament to our conventional fighters’, warning that: ‘As soon as they are available in sufficient numbers, and as soon as the enemy has developed suitable tactics … they will doubtless be employed systematically against our strategic bombers.’ The directive continued that the deployment of such aircraft could have serious repercussions for the tactical air forces supporting the Allied advance, and pose a danger to ground forces should the Me.262 be utilised as reconnaissance and/or ground attack platforms. To answer this danger, the strategic air campaign was to: ‘employ the necessary amount of strategic effort to avoid this grave threat’, adding that the *Luftwaffe's* jet production, training and operational establishments would now become primary objectives for attack.[27] Nonetheless Overy noted that the Me.262 suffered technical problems with its turbojet engines. He also argued that while a significant number of the aircraft were constructed, over 500, it appeared too late in the war to have any discernable impact on Allied air superiority. Furthermore, Overy observed that representations made by *General der Flieger* Karl Koller, chief of the *Luftwaffe* general staff, to Göring for the re-equipment of *Luftwaffe* fighter units with Me.262s were greeted angrily by the latter, while Germany's *Führer* Adolf Hitler only belatedly agreed to the re-rolling of the Me.262 as a fighter rather than a fighter-bomber.[28] The only other major difference in the targeting priorities from the November directive compared to the January directive was the emphasis on attacks against ‘U’ boat submarine installations as part of the Allies' ongoing operations against naval targets.[29]

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[27] *Ibid.*
[28] Overy, *The Bombing War*, p.387, p.396.
[29] ‘15th January, Directive No.3 for the Strategic Air Forces in Europe’, in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.182.

As with the November directive, the publication of the January directive prompted a letter from Bottomley to Harris detailing what the directive would mean for Bomber Command. Writing on 19 January, Bottomley stipulated that the OCA effort against *Luftwaffe*: 'jet production, training and operational establishments, now becomes a primary objective for attack.' He added that 'no fixed order of priority in relation to the petroleum industry and communications has been accorded to this target system, since operations against it are in effect security measures which must be adjusted from time to time in accordance with the development of this threat'. Mirroring the January directive, Bottomley's letter to Harris stressed the need for the Command to intensify attacks against U-boat targets.[30] Much like his response to the November directive, Davis-Biddle observed that Harris again expressed misgivings regarding the targets he was to attack, believing that continued attacks against urban targets as opposed to oil facilities, which he argued could be dispersed or buried underground, represented a more productive employment of Bomber Command. As Davis-Biddle noted: 'Harris remained as committed as ever to city bombing, which he felt certain was responsible for Germany's distress and for the ongoing advance of Allied ground forces.'[31]

The efforts of 100 Group to jam the electronic elements of the IADS continued to play an important role in keeping Bomber Command losses at a rate of one percent of sorties despatched. During a conference held by Bottomley on 20 February, he: 'referred to the

[30] '15 January 1945. Air Marshal Sir Norman Bottomley (Deputy Chief of the Air Staff) to Air Chief Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.179, p.180.
[31] Davis-Biddle, *Rhetoric and Reality in Air Warfare*, p.251.

present low casualty rates being experienced by Bomber Command in their night operations'.[32] In an ensuing discussion:

> It was generally agreed that our present (ECM) measures are largely responsible for this satisfactory state of affairs, and that the enemy is undoubtedly baffled at the moment by the measures taken in routeing, diversions and method of execution of attacks.[33]

While the airborne ECM efforts of 100 Group were making their presence felt *vis-à-vis* the IADS, ground-based ECM activities were continuing. With the Allied presence firmly established in Western Europe following the conclusion of Overlord, and the liberation of France, 80 Wing redeployed to the continent. The *rationale* behind 80 Wing's deployment was to position its ECMs close to Germany to ensure that these countermeasures were as effective as possible. The technical reasons for this are detailed in the previous chapter. After an abortive plan to position 80 Wing's headquarters in eastern Belgium, near the German border, which was delayed because of the German Army's offensive in the Ardennes, satisfactory headquarters were found at Chateau Brifaut on the western outskirts of Brussels; which were declared operational on 9 February. 80 Wing's headquarters were joined by the constituent parts of its deployment in the form of the Wing's 80SC (Communication Jamming) unit which deployed to Uden in the southern Netherlands. Meanwhile, the 70SF (Radar Jamming) and 71SF units were deployed to the southern Netherlands, near Leende, close to the site of 80SC. Nine days after the establishment of its headquarters 80 Wing's continental deployment performed its first application of jamming in anger on 18 February when 70SU and 71SU were directed to perform jamming across wavebands of 70MHz to 100MHz, and 430MHz to 600MHz with the intention of jamming *Luftwaffe* FuMG-80 and

[32] 'Radio Countermeasures Devices, Minutes of DCAS Conference, 20 Feb 1945, Bomber Command Night Operations', AIR 20/8071.
[33] *Ibid.*

FuMG-62D radars. Additional jamming units were deployed to the continent to intensify the Wing's efforts: On 3 March, the 81SC unit was activated at Bree in northwest Belgium, close to the Belgian-German border. This was followed with the activation on 31 March of the 82SC Unit in Geldern, followed by the 83SC Unit deployed to Julich which was activated on 9 April; with both units located close to the Dutch-German border. Furthermore the Allied advance in Western Europe enabled 80 Wing to move its jamming units deeper into German territory. For example, the 84SC and 85SC units were deployed to the city of Koblenz in western Germany between late March and early April, yet the speed of the advance resulted in 80 Wing withdrawing these units before they were declared operational. On 4 May 100 Group instructed 80 Wing to withdraw all of its deployed units to Wenduine on the Belgian coast while the Wing's forward deployed headquarters at Chateau Brifaut was closed on 11 May. By 16 May, 80 Wing's deployment on the continent was at an end, and the headquarters and its constituent SC and SF units had returned to RAF Swanton Morley in Norfolk. The Wing was formally disbanded on 24 September, and replaced by the Radio Warfare Establishment which was activated in October at RAF Watton in Norfolk.[34] As outlined above, the Allied Combined Chiefs of Staff had made their objectives regarding the strategic air campaign clear in a number of directives published in November, January and April. The deployment of 80 Wing's jamming elements to the continent was as much a reaction to the continued threat posed by the IADS, as a result of a need to ensure as much ECM support was in place as the strategic air campaign continued in the final months of the war. Given that 80 Wing performed its jamming in support of Bomber Command operations as and when they were mounted, this illustrated that these SEAD efforts were practiced at the Localised level. Regarding the method of application, 80 Wing utilised the Mass SEAD technique. Although

[34] AIR 41, pp.210-211, p.217, p.212.

Dougherty's definition of Mass SEAD stressed that this: 'relies on a large number of aircraft to saturate and overwhelm an air defense (*sic*) system at a given point,'[35] in this instance the large number of 'aircraft' were the jamming systems brought to bear by the Wing to saturate and overwhelm the IADS by performing wideband jamming across the frequencies used by the force's radars and radio communications/navigation systems.

By March 1945, much of western Germany was in Allied hands and Bomber Command was performing a significant number of raids deep into parts of the country not yet under Allied control, mainly in the east. It was in this month that the Command suffered a loss rate of 1.5 percent for sorties despatched during night operations; its highest loss rate for night operations during the period under discussion.[36] The official record argues that this loss rate was the result of *Luftwaffe* aircrew receiving earlier warnings of incoming Bomber Command sorties, and blames this comparatively high level of night losses on *Luftwaffe* fighter controllers being able to anticipate with increasing precision the likely penetration points of the Command's sorties into Germany. It continued that this was a result of fighter controllers detecting the location of Bomber Command's Mandrel Screen, examining local weather conditions to determine areas favourable for ingress and thus deducing the potential vectors of the Command's aircraft. This official explanation appears to indict why losses remained high in March despite the *Luftwaffe* suffering from progressively degraded FuMG-80 coverage during this period. Put simply, the degraded FuMG-80 coverage was a result of the Mandrel Screen and by fighter controllers improving their ability to determine when and where their FuMG-80 radars were being jammed, and taking weather conditions into account, they could discern the possible ingress and egress routes. Furthermore, between mid-March and mid-

[35] Dougherty, *Defense Suppression*, pp.26-27.
[36] AIR 14/2911, pp.30-31.

April, the Allies made significant gains in Western Europe, with much of western Germany falling under their control. This occupation of German territory progressively deprived the *Luftwaffe* of FuMG-80 and FuMG-62D coverage as these radar stations fell under Allied control. This might explain why Bomber Command losses dramatically reduced in April, to an average of 0.4 percent for all sorties despatched.[37]

Addison posited an interesting argument regarding this increase in night losses. He claimed that while the number of engagements of the Command's aircraft by fighters had decreased: 'The rising incidence of our losses at night, and the diminishing score of our night fighters, prove however that any such quantitative decrease has been more than offset by an increase in quality.' He attributed this to the *Luftwaffe* only using 'ace' fighter aircrews in Western Europe, observing that: 'by reason of their skill, they are likely to be very successful, if and when, they do gain contact with the bomber stream'.[38] A final factor noted by the official record was the discipline exercised by controllers in holding back their fighter reserves until they had ascertained the location and vectors of the Command's sorties. Bomber Command responded to this challenge by using several feint raids with the intention of sowing as much confusion into the IADS as possible.[39]

Nevertheless, the increase in Bomber Command night losses in March 1945 caused Addison to sound a note of caution. While the conference chaired by Bottomley in February 1945 discussed above extolled the role played by ECMs in helping to maintain low Bomber Command casualties, Addison warned in late-March that the losses had underscored that

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[37] AIR 41/56, pp.221-222.
[38] '100 Group Extracts from AOC's DO Files, Letter from AVM Addison to AM Sir Robert Saundby, Deputy Air Officer Commanding-in-Chief, Headquarters, Bomber Command, 31 March 1945', AIR 14/2657.
[39] AIR 41/56, pp.221-222.

ECMs alone were not a panacea for keeping casualties acceptably low. He argued it was essential that fighters be prevented from penetrating Bomber Command's Main Force, particularly as these aircraft approached their targets.[40] Regarding the ECMs which the Command was bringing to bear against the *Luftwaffe*, he stated that:

> (E)ven were they 100 percent perfect (and they are not) they still would not prevent some of the Huns from stumbling into the stream whereupon, as we know, a skilful night fighter should have but little difficulty in inflicting great damage.[41]

Cognisant of the inability of ECMs to offer 100 percent protection to Bomber Command's aircraft at this stage in the war, Addison argued that the Command should apply its energies to creating large diversion forces so as to confuse *Luftwaffe* fighters as to the location of the Main Force, and its intended target. He drafted a paper with this in mind on 3 April entitled *The Scape Goats of Bomber Command*, which stressed the tactical benefits of mounting diversionary operations against the *Luftwaffe*. In the document, he noted that the force had displayed an increasing aptitude to correctly guessing Bomber Command's targets on any given night of operations, and then 'sending his fighters to the right area at the right time to await the arrival of the bombers'. The intention of using diversionary forces, the document continued, was to change the appearance of the air situation for the *Luftwaffe*, by causing the IADS to make a 'false appreciation' of the Command's intended targets, and for the *Luftwaffe* to ultimately 'send (its) fighters to any areas other than those to which the bombers were going'. Added to this, Addison observed that the success of the feint effort was not only in deploying it when the Main Force was active, but also when it was not, so as to continually

[40] '100 Group Extracts from AOC's DO Files, Letter from AVM Addison to AM Sir Robert Saundby, Deputy Air Officer Commanding-in-Chief, Headquarters, Bomber Command, 31 March 1945', AIR 14/2657.
[41] *Ibid.*

confuse the *Luftwaffe*.[42] This reflected Addison's Campaign level-minded approach to SEAD that he had exhibited since taking command of 100 Group.

The successful employment of diversionary tactics writ large by Bomber Command, Addison asserted, was dependent on the aircraft available to 100 Group, and to Bomber Command in general. This was because the Group had to perform jamming operations, much as they would in support of a genuine Main Force operation via the employment, for example, of the Mandrel Screen/SWF combination.[43] Meanwhile additional Bomber Command aircraft beyond 100 Group were required to drop target indicators, flares and incendiary bombs, to mimic the activities of the Main Force.[44] Addison had written to Saundby in late March warning that 100 Group had no aircraft available to exclusively support these diversionary efforts. While the Group had hitherto performed diversionary efforts Addison stated that this was done by employing any surplus Group aircraft at any given time once its obligations in terms of ELINT collection, jamming, fighter protection and OCA had been met. The downside, he noted, was that mounting diversionary efforts had caused the Group to drive its squadrons 'somewhat mercilessly'. Addison conceded that the arrival of 462 Squadron in the Group's order of battle had assisted in the provision of the diversionary effort.[45] Nonetheless, he continued that this unit would offer little more than a temporary alleviation of the situation, and warned Saundby that:

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[42] 'The Scape Goats of Bomber Command, 3rd April 1945', AIR 14/2657.
[43] 'Brief Survey of the Operational Functions of No.100 Group, 4 November 1944', AIR 14/2657.
[44] 'The Scape Goats of Bomber Command, 3rd April 1945', AIR 14/2657.
[45] '100 Group Extracts from AOC's DO Files, Letter from AVM Addison to AM Sir Robert Saundby, Deputy Air Officer Commanding-in-Chief, Headquarters, Bomber Command, 31 March 1945', AIR 14/2657.

> On the whole, therefore, the strength of our diversionary force in the immediate future is likely to wane and so an important part of your bomber support programme must suffer unless some other expedient can be introduced.[46]

Addison's arguments were heeded and on 8 April, Air Commodore Hugh Walmsley, senior air staff officer for night bombing at Bomber Command wrote to Addison to inform that the Command would provide a small force of additional aircraft to equip the Group's 171 and 199 Squadrons to supplement these units' Mandrel Screen efforts with both squadrons increased in strength by four Halifax-BIIIs each.[47] This would ensure that 100 Group could continue to deploy a robust Mandrel Screen as at least two Mandrel Screens were required to be employed in two different areas to create as much confusion as possible on any given night. This was particularly important when time intervals of two and a half hours or more were expected between two Command calling for the activation of separate Mandrel Screens to protect these respective efforts. In addition the Mandrel Screen was required in its own right to assist the continual attrition of the IADS, in line with Addison's and Harris' Campaign SEAD intentions.[48]

The relatively high level of night losses experienced by Bomber Command in March 1945 may have also been the result of the introduction of the *Luftwaffe's* FuG-216/217/218 AI radar. Once the existence of the new radar had been determined in March 1945 work commenced in 462 Squadron to adapt the Piperack ECMs used by this unit's aircraft to jam this radar. This modified ECM entered service in April 1945 but judging whether it was

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[46] *Ibid.*
[47] AIR 14/2911, pp.31-32.
[48] 'No. 100 (BS) Group RCM Operations, Aircraft Establishment of No.171 and 199 (Bomber Support) Squadrons, Letter from Air Vice-Marshal Addison to the Undersecretary of State for Air, 5 April 1945', AIR 14/736.

successful is open to debate given the rapid Allied advance on the ground that was bringing the war to a close.[49]

April - May 1945: The Strategic Air Campaign comes to an end

Concerns regarding *Luftwaffe* AI radar continued during the final month of the war, and in April fears regarding centimetric wave radar were raised once again, on this occasion during a meeting of the RCM Board held on 10 April. The ORS' concerns regarding the potential advent of centimetric wave radar, first articulated in December 1944, had been echoed by Bottomley in February 1945 who had sounded a note of caution and warned that: 'the present low casualty rate is not likely to continue for long if the enemy is able to bring into excessive use certain of his countermeasures using centimetric technique'. He continued that Tait should indicate what ECMs could be brought to bear against such centimetric techniques: 'to accelerate the development of equipment that will keep us ahead of the enemy.'[50] During this meeting Jones detailed that a captured enemy document had disclosed continuing research work on four ground-based air surveillance radar designs. These were to transmit at frequencies of 500MHz and 3.3GHz, with two systems to transmit at frequencies of 1.1GHz. He added there was no indication that, as of April 1945, these radars were yet in service with the *Luftwaffe*.[51] Fortunately, Bomber Command would not have to contend with these radars during the remainder of its operations over Germany. Overy argued that the development of centimetric wave radar mirrored the deployment of the Me.262 with too few aircraft available

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[49] AIR 41, pp.159-160.
[50] 'Radio Countermeasures Devices, Minutes of DCAS Conference, 20 Feb 1945, Bomber Command Night Operations', AIR 20/8071.
[51] 'Radio Counter Measures Board Terms of Reference and Minutes of Meetings, Nos. 1-38, 24 March 1942 to April 1945; RCM Board, Minutes of the 38 Meeting, held in Room 11, 2nd Floor, Air Ministry, Whitehall, on Tuesday, 10 April, 1945', AIR 20/8213.

to accommodate radar technology developed too late in the war to make any appreciable difference to Allied air superiority.[52]

The final directive regarding the targeting priorities for the strategic air campaign was issued by the Allied Combined Chiefs of Staff on 16 April. Throughout the last six months of the war the Allies had progressively liberated an increasing amount of territory from Germany's control. By 19 April most of the Netherlands, and all of Germany west of the Elbe River running roughly south to north from Czechoslovakia's northern border with Germany to the German North Sea port of Cuxhaven had been occupied by the Allies, with the Red Army advancing west towards Berlin. Breaking with previous directives, the 16 April directive omitted the 'progressive destruction and dislocation of the German military, industrial and economic systems and the direct support of land and naval forces'.[53] Instead, it stressed that: 'The main mission of the Strategic Air Forces is now to give direct assistance to the land campaign.' In addition to assisting the Allies' efforts on the ground, the strategic air campaign was to continue its attacks against oil and transportation targets. Meanwhile, attacks against the *Luftwaffe* reverted back to their profile as of the November directive, with: 'policing attacks against the (*Luftwaffe*) … continued to the extent necessary to ensure tactical conditions which will prevent effective interference with our ground and air operations', while efforts against *Kriegsmarine* U-boats were to continue.[54]

As previously, Bottomley sent a letter to Harris, this time on 5 May as the Second World War in Europe was drawing to a close, stressing that the strategic air campaign must continue to

[52] Overy, *The Air War*, pp.201-202.
[53] '1 November 1944. Directive No.2 for the Strategic Air Forces in Europe', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.178.
[54] '16 April 1945. Directive No.4 for the Strategic Air Forces in Europe', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, pp.183-184.

assist land operations.[55] On the night of 25/26 April Bomber Command performed its final offensive operations of the Second World War when 5 Group performed an attack against an oil storage depot in Tønsberg, southern Norway, with offensive operations ceasing on the night of 2/3 May when 8 Group attacked the German port of Kiel on the Baltic Sea and *Luftwaffe* airfields in northern Germany.[56] 100 Group performed its last hostile action on the night of 2/3 May protecting Bomber Command aircraft by deploying the Mandrel Screen/SWF combination in the vicinity of Schleswig in northern Germany while a light attack was performed by the aircraft of 8 Group against Kiel. As 100 Group's *Review of Operations* notes: 'Little fighter reaction was encountered, probably due to disorganisation of enemy plotting, undoubtedly further increased by this night's feint attack.'[57] Bomber Command operations continued between 3 May and 8 May, but these were restricted to humanitarian missions delivering food to the Netherlands and repatriating Allied prisoners of war. On 4 May Germany signed the act of surrender with the Allies represented by Field Marshal Bernard Montgomery, commanding the Allied 21st Army Group, at Luneburg Heath, northern Germany. On 8 May the Air Ministry notified Bomber Command that: 'all German land, sea and air forces will cease active operations at 0001/B hours on 9 May', formally bringing the strategic air campaign to an end.[58] With hostile operations over the Group performed one last major action before its disbandment in December: Exercise Post Mortem commenced on 25 June and concluded on 5 July. This was mounted to ascertain the effectiveness of 100 Group's ECMs and EW techniques against a section of the *Luftwaffe* IADS which remained relatively intact in Denmark, and to perform in-depth interrogations of

[55] '5 May 1945. Air Marshal Sir Norman Bottomley (Deputy Chief of the Air Staff) to Air Chief Marshal Sir Arthur Harris', in Frankland, Webster, *The Strategic Air Offensive Against Germany*, p.184.
[56] AIR 41/56, p.244.
[57] AIR 14/2911, p.32.
[58] AIR 41/56, p.244.

Luftwaffe air defence personnel.[59] Following the completion of this exercise 100 Group was progressively disbanded and finally ceased to exist on 17 December.

Conclusions

The established body of literature examines several facets of Bomber Command's EW efforts during the final sixth months of the war. The authors therein made claims regarding the Command's aircraft and aircrew saved by 100 Group's efforts. They added that the ECMs which the Command introduced caused a corresponding strain on the German scientific establishment as it sought ways and means to nullify these, while also causing a loss of morale amongst *Luftwaffe* fighter aircrew. The literature argued that Bomber Command's EW efforts were cyclic and that for every ECM, or EW tactic or technique that the Command introduced, the *Luftwaffe* would develop a riposte. Arguments were articulated that the Command's actions, in particular the fighter and fighter-bomber force which was by now accompanying the efforts of the Main Force were also adversely affecting the strength of the *Luftwaffe* fighter force as were the activities of the Mandrel Screen and SWF. Streetly noted that Addison articulated his intentions to continually attrit the *Luftwaffe* IADS.[60] Yet this was the only discussion of the intentions behind the Command's EW efforts in his work which avoided the examination of how the Command's EW policies and SEAD posture developed throughout the entirety of the conflict.

During the final six months of the war, Bomber Command pursued both reactive and proactive EW policies. The continued use of the Mandrel Screen and SWF were clear

[59] Streetly, *Confound and Destroy*, p.114.
[60] *Ibid.*, p.143.

examples of this as they were mounted not only as a response to the continuing threat posed by *Luftwaffe* radar, but also to precipitate the long-term degradation of the IADS' effectiveness. The raising of concerns regarding the advent of centimetric wave radar also exemplified the Command's proactive EW posture although ultimately the end of the war would preclude it from having to counter this threat. Other efforts undertaken by 100 Group, such as the deployment of 80 Wing to the continent, were the result of proactive EW policy given the threat that the IADS could continue to pose to Bomber Command aircraft.

That 100 Group would perform EW operations when the Main Force was not operating was a clear example of the Command practicing Campaign-level SEAD, according to Addison's long-term objective that the potency of the IADS had to be progressively degraded. This was also the case for the use of the Mandrel Screen and SWF which was similarly deployed to provide the long-term attrition of the IADS, hence chiming with Campaign SEAD approaches. Nevertheless, the employment of the Mandrel Screen/SWF combination was also an example of SEAD being applied at the Localised level as this assisted the protection of Main Force aircraft during their operations. As they had been since their inception, both the Mandrel Screen and SWF applied the Manoeuvrist and Stealth/Surprise SEAD approaches. Similarly, 80 Wing's jamming efforts on the continent represented an example of Localised SEAD using the Mass approach. Addison's encouragement towards the end of the war to enlarge the feint efforts performed by the Command in the wake of rising night losses in March was also indicative of his Campaign-level SEAD thinking in that such operations should be continually performed with the objective of wearing down the IADS regardless of whether the Main Force was operating. Thus the final six month of the war saw the Command adopt proactive and reactive EW policies implemented at the Campaign and Localised levels, using the Manoeuvrist, Stealth/Surprise and Massed approaches.

Revisiting Addison's writing in October 1944, when he had stated that: 'We have got the Hun rattled and it is up to everyone who has a hand in radio countermeasures to do his utmost to ensure that he stays that way.'[61] The EW policies and SEAD efforts of Bomber Command during the final six months of the war illustrated that his intentions had finally become a reality.

[61] 'Radio Countermeasures in Bomber Command Operational Summary No.4, 20 October 1944', AIR 20/8071.

CONCLUSIONS

The intent of this thesis was to determine the proactive and/or reactive characteristics of Bomber Command's EW policies, and its resulting SEAD postures, during the Second World War. Ultimately Bomber Command enacted both proactive and reactive EW policies at the Campaign and Localised SEAD levels using a combination of Manoeuvrist, Mass and Stealth/Surprise approaches.

The Command's proactive and reactive EW policies were illustrated by a number of specific actions: For example its use of ECMs, witnessed in March 1941 with the deployment of the IFF Mk.1 set by Command aircrews in the questionable belief that this would dowse *Luftwaffe* searchlights by jamming the FuMG-62D radars believed to be controlling them, was the first illustration of the Command adopting a reactive EW policy as a response to the searchlight threat, with this policy being enacted at the Localised level. Meanwhile Bomber Command's first major articulation of an EW policy in October 1942 was reactive in nature with the decision to adopt the Mandrel, Ground Grocer, Ground Mandrel, Shiver, Tinsel and Window ECMs in an effort to mitigate losses by degrading the radar and radio communications/navigation systems employed by the *Luftwaffe* IADS. Examples of the Command's proactive EW policy included the decision to develop a VHF radio jammer in anticipation of *Luftwaffe* frequencies changing following the deployment of Tinsel to jam *Luftwaffe* HF radio in December 1942. This crystallised with the development and deployment of the ABC and Ground Cigar ECMs.

Examples also exist of the Command's EW policies being both proactive *and* reactive: In 1943, Harris' rationale regarding 100 Group's creation was to raise an organisation which would direct its efforts in a holistic fashion against all aspects of the IADS. His approach was illustrative of both proactive and reactive EW policy: reactive as it was responding to threats that the Command faced, and would continue to encounter; and proactive as dedicated EW aircraft would be required to accommodate new ECMs as and when new *Luftwaffe* radar and radio communications/navigation systems and tactics were discovered. Yet, during the first six months of the Group's existence, the Command was reliant on ground-based ECMs. To this end, countermeasures such as Dartboard and Rayon were the result of reactive EW policies directed against the *Luftwaffe's* Ottokar and Benito radio navigation systems.

Much like Harris' rationale for the creation of 100 Group, Addison's request in August 1944 for additional heavy aircraft to perform EW epitomised proactive EW policy, as this was made in anticipation of the future reinforcement of the IADS, and amid concerns over the ability of the TRE to stay abreast of German scientific ingenuity. Proactive EW policy was also witnessed in December 1944 following concerns that the *Luftwaffe* might deploy centimetric wave AI radar in response to the deployment of the Mandrel Screen and SWF, although ultimately such concerns would not materialise. Additionally, reactive and proactive EW policy was illustrated by 80 Wing's deployment to the continent to apply ECMs against the *Luftwaffe* IADS.

These proactive and reactive EW policies were implemented as the Campaign and Localised SEAD levels through the application of Manoeuvrist, Mass and Stealth/Surprise approaches. Initially, the Command's efforts to reduce the threat posed by the IADS did not extend beyond gathering ELINT concerning the *Luftwaffe's* ground-based air surveillance and FC/GCI radars. This was the Command's first example of Campaign level SEAD as ELINT collection aided the construction of an electronic ORBAT of the IADS to ascertain how its radar and radio communications/navigation systems could be electronically attacked in the future. When Bomber Command commenced area attacks writ large in July 1941, the corresponding increase in losses spurred the adoption of ECMs as a Campaign level SEAD measure designed to reduce casualties as the strategic air campaign broadened. Nevertheless, the decision taken in October 1941 to allow the use of ECMs was a false dawn following the Command's suspension of operations in late 1941, and it would not be until October 1942 that the Command would articulate a coherent, holistic EW policy.

When the Command commenced its deployment of ECMs following the October 1942 decision, countermeasures such as ABC and Ground Cigar were deployed at the Localised level and applied using the Mass and Manoeuvrist approaches. Meanwhile, the Mandrel and Carpet ECMs directed against *Luftwaffe* ground-based air surveillance and FC/GCI radars were also employed at the Localised level but applied Stealth/Surprise, while ECMs such as the Fidget ground-based countermeasure intended to spoof *Luftwaffe* fighter beacons were used at the Localised level to apply Manoeuvrist SEAD with other ground-based ECMs such as Dartboard, Drumstick and Rayon, also deployed at the Localised level, applying Mass.

Much as they reflected both reactive and proactive EW policy, Harris' arguments regarding the creation of 100 Group illustrated the Campaign SEAD thinking he had exhibited since becoming AOC-in-C of Bomber Command in February 1942 with the Group's activation intrinsically linked to the overall success of the strategic air campaign: The Group's ELINT gathering activities were examples of Campaign and Localised SEAD as they were intended to support the provision of ECMs on any given night of operations, as well as enabling the Command to continually refine its deployment of ECMs against the IADS over the long term. In addition, Addison's expectation that 100 Group would perform its operations to steadily attrit the IADS clearly exemplified Campaign level SEAD and Operation Overlord would represent the first opportunity for him to demonstrate this via the Command's EW efforts to degrade the performance of the IADS radar and radio communications/navigation systems with ECMs to protect the invasion's airborne component and create increasingly favourable conditions for friendly operations.

In the wake of Overlord, the *Luftwaffe* reorganised its fighter defences while technical considerations, such as ground-based air surveillance radar frequency extensions, caused the Command to rethink its use of the Mandrel ECM. This resulted in 100 Group deploying the Mandrel Screen which was first used in support of Command operations in mid-June 1944 alongside the SWF deployed from July. While the Mandrel Screen was deployed at the Localised level using the Manoeuvrist and Stealth/Surprise approaches to protect Main Force aircraft during their specific operations, it was also an example of Campaign SEAD as the screen was not only deployed when the Main Force was flying, but when operations were not occurring with the intention of wearing down the IADS thus reflecting Addison's and Harris' intentions to this effect.

During the final year of the war, the deployment of the Mandrel Screen and the SWF remained at the core of the Command's SEAD efforts with Harris recognising the Campaign SEAD approach to which the screen was integral. He made similar observations regarding the

SWF which, by the final six months of the war, had paid dividends at the Campaign SEAD level as noted in December 1944 by the Command's ORS. Similarly an April 1945 paper written by Addison stressed the importance of feint and diversionary measures in keeping Command losses down in light of an increase experienced that March; a further example of his Campaign level thinking. Similarly, the deployment of 80 Wing to the continent saw EW applied at the Localised level, using the Mass approach. The final six months of the war also witnessed the deployment of ECMs at the Localised level such as the Carpet-III countermeasure which applied the Stealth/Surprise approach, plus Piperack and Jostle-IV directed against *Luftwaffe* AI radar and radio communications respectively. These two ECMs were also used at the Localised level, although applied Mass.

Areas of Future Research

Although this thesis ascertained the nature of Bomber Command's EW policies and their subsequent levels of application via SEAD, opportunities for future research exist regarding the Command's OCA and SEAD efforts writ large during the Second World War. These include Bomber Command's kinetic efforts against IADS targets such as individual ground-based air surveillance and/or FC/CGI radars, GCI centres, radio beacons and radio transmitters, and the extent to which such attacks were made and if not, why the Command desisted from such a course of action? Secondly, there is scope to examine the extent to which RAF doctrine at the time prescribed SEAD, and the degree to which the Command's efforts in this regard accorded with doctrinal expectations. Moreover, the historical record would benefit from an examination of the extent to which the contemporary British defence industry proposed solutions to the EW and SEAD challenges faced by the Command: Was industry simply told to go and produce ECMs developed by the TRE, or was a two-way process at work by which industry also developed and recommended potential EW systems and techniques to Bomber Command?

Another potential area of future academic examination includes the influence of Bomber Command's SEAD efforts on SEAD and EW policy *vis-à-vis* post-war airpower, both in the RAF and beyond. The legacy of Bomber Command's actions concerning the *Luftwaffe* IADS is most visible concerning the levels at which SEAD has been performed by Western air forces in general since the end of the Second World War. Essentially the ability to perform Campaign level SEAD passed from the RAF to the US armed forces, notably the USAF, USN and USMC, during the years of the Cold War and beyond. Simultaneously over this period, the ability of the RAF to perform Campaign and Localised SEAD unilaterally at the operational level progressively declined, as such capabilities were increasingly assumed by the US armed forces.

The Demise of RAF Campaign SEAD

Bomber Command's role changed considerably following the end of the Second World War. The detonation of the atomic bombs above the Japanese cities of Hiroshima and Nagasaki which helped to end the conflict in August 1945, and Britain's subsequent detonation of its first atomic device on 3 October 1952 in Western Australia, paved the way for the Command to become the custodians of the UK's nascent nuclear deterrent. The explosive force which could be unleashed on a city by raids of several hundred of Bomber Command's aircraft during the Second World War could now be accomplished by one aircraft from the Command's V-force of strategic bombers carrying a single atomic weapon. As noted in this thesis, Harris and Addison saw Bomber Command's EW policies and SEAD postures through a Campaign-level prism which would progressively attrit the *Luftwaffe* IADS and thus support the overarching aims of the strategic air campaign. Both the strategic air campaign and the SEAD effort to support it were seen as processes of attrition that would wear Germany down to such an extent that she could no longer continue the conflict.

The advent of nuclear weapons and the development of the V-force in the 1950s consigned this approach to history. The sheer destructive power enclosed within an atomic bomb no longer necessitated night after night of attacks against urban targets, when a significant quantity of an urban target could be destroyed with a single detonation: A V-force bomber would not have to perform repeated attacks against one or more targets on successive days or nights to achieve such an effect. It would merely need to once avoid the potency of an IADS, in this case the one protecting the Soviet Union, to deliver its weapon against its allotted target. It has even been stated that for the V-force the mission was in effect a one-way sortie given that it was more than likely that their own bases back in the UK would have been devastated by either a pre-emptive or retaliatory Soviet nuclear attack, along with much of the country, rendering any return trip to the UK and continued participation in hostilities, unlikely.[1] As each V-force aircraft had for all intents and purposes one mission to perform with a large proportion, if not all, of the aircraft probably being scrambled simultaneously to reach their targets, there was arguably little point performing Campaign-level SEAD against the Soviet IADS in a bid to create increasingly favourable operational conditions.

Moreover RAF war plans involving the V-force make no mention of any SEAD capability or OCA effort to sanitise hostile airspace prior to, or during, the bombers sorties. Instead, the

[1] A. Tregenza, 'How capable was the V-Bomber Force militarily of delivering Britain's nuclear deterrent in the late 1950s and 1960s?' in *Royal Air Force Air Power Review: Volume 7, Number 1* (London: Royal Air Force, Spring 2002), p.132.

OCA effort of the V-force would not extend beyond the hopeful physical saturation of the Soviet IADS as it was expected that these aircraft would be part of a larger air *armada* of hundreds of USAF and *Armée de l'Air* (French Air Force) strategic bombers attacking targets in the Soviet Union once war had begun, alongside a multitude of incoming intercontinental and other nuclear-armed ballistic missiles. Beyond saturation the V-force was to rely on its aircraft's own ECMs for protection as they ingressed hostile airspace, along with their flight profile which, from 1960, would assume a low altitude as Soviet high-altitude SAMs proliferated.[2] The campaign-level requirement to continually wear down a hostile IADS became superfluous in favour of a Localised SEAD posture which would require an individual aircraft to protect itself for the duration of its mission to deliver its weapon. This situation would persist until the custody of the UK's independent nuclear deterrent passed to the Royal Navy in the late 1960s with the deployment of the UGM-27 Polaris submarine-launched ballistic missile. Put simply, in the immediate post-war era the RAF had no operational need for Campaign-level SEAD and would lose the capability to perform this unilaterally.

While the V-force' reliance on Localised SEAD presaged the RAF's retreat from Campaign SEAD, the US involvement in the Vietnam War witnessed the overtures which would result in the USAF, USN and USMC becoming the West's pre-eminent Campaign SEAD force, illustrating how this baton had passed from the RAF to the US armed forces. One of the key airpower threats which the US had to address during the conflict, alongside North Vietnamese Air Force fighters, was the missile threat particularly from SA-2 SAMs supplied to North Vietnam by the Soviet Union. As noted in chapter one the USAF countered this threat by

[2] *Ibid.*, pp. 113-133, p.128.

developing the Iron Hand and Wild Weasel air defence suppression aircraft. The advent of the Wild Weasel force from 1965 would represent one of the first post-war incarnations of a Campaign-level SEAD posture, alongside the actions of the Israeli Air Force, also discussed in more detail in chapter one. The development and deployment of the Wild Weasel force was a clear demonstration of Campaign-level SEAD: The strength of North Vietnam's air defences, and its IADS in general, posed a serious challenge to the ability of the US to exercise air power. As a means of comparison, during the Second World War, US forces suffered total aircraft combat losses of 19,030 aircraft for 2,498,283 combat sorties; an attrition rate of 0.76 percent.[3] During the US involvement in Vietnam the USAF flew 219,407 combat sorties and lost 1,437 aircraft, leading to an attrition rate of 0.65 percent, close to the levels US forces experienced during the Second World War, and notably higher that the 0.2% attrition rate the US had experienced during the Korean War. Therefore, the potency of the North Vietnamese IADS was sufficient to pose a significant threat to the conduct of the air war, hence the Wild Weasel force performing a Campaign-level SEAD function, as much as a Localised one, to protect strike packages of aircraft during their specific missions. As Hewitt noted: '(I)n a prolonged SEAD campaign, or where specific threats need to be cleared to open the way for penetrating aircraft, the Weasel makes sense.'[4] Whereas 100 Group had been disbanded at the end of the Second World War, the US chose to raise a dedicated SEAD force in the form of the Wild Weasel and later Viper Weasel force, alongside similar capabilities within the USN and USMC. As the discussion below articulates these forces became the pre-eminent SEAD capability available to the US and her allies in future conflicts.

[3] C. Bolkcom, *Military Suppression of Enemy Air Defences (SEAD): Assessing Future Needs*, (Washington DC: Congressional Research Service, 2005), p.4.
[4] W.A. Hewitt, *Planting the Seeds of SEAD: The Wild Weasel in Vietnam: A Thesis Presented to the Faculty of the School of Advanced Airpower Studies for the Completion of Graduation Requirements*, (Maxwell Air Force Base: School of Advanced Air Power Studies, Air University), p.16, p.30.

Nevertheless the RAF did perform one final example of unilateral SEAD, notably during Operation Corporate, the British military response to the invasion of the Falkland Islands by Argentina in spring 1982. As articulated in chapter one the RAF performed a series of long-range strikes against a number of Argentine military targets on the islands as part of the Operation Black Buck effort. This included missions flown by Vulcan-B2 strategic bombers against Argentine ground-based air defences on the islands, notably an AN/TPS-43F ground-based air surveillance radar which was providing the FAA with a RAP of the Falkland Islands *locale*. This was an example of Campaign level SEAD as the radar's destruction would have theatre-wide effects regarding the ability of the FAA to employ air power in support of its military and strategic objectives, and against the British forces seeking to recapture the islands. The Black Buck operation remains the Campaign-level exception to the Localised-level SEAD posture which the RAF adopted in the post-war era.

The RAF's migration to this SEAD posture crystallised with the procurement of the ALARM anti-radiation missile. The RAF's decision to procure the ALARM squarely placed the RAF into the role of an air force capable of performing Localised SEAD against an adversary as opposed to one capable of unilaterally performing Campaign level SEAD against all, or a significant part, of an adversary's IADS. The RAF had deployed the Hawker-Siddeley/Matra AS-37 Martel anti-radiation missile onboard the Blackburn Buccaneer S.2B fighter although this weapon was never fired by the force in anger. The RAF took the decision to procure the ALARM in the late 1970s.[5] The acquisition of the missile, as noted by Andrew, reflected the RAF's changing SEAD posture in the post war, and post V-force, era:

[5] D.R. Andrew, 'Vorsprung Durch Technik' in *Royal Air Force Air Power Review, Volume 3, Number 3*, (London: Royal Air Force, Autumn 2000), p.101.

> At the time of the procurement, during the Cold War, the perceived main role for RAF SEAD assets was to clear a gap through the robust SAM belt along the Inner German Border to allow the then new Tornado-GR1 bombers passage to their Offensive Counter Air targets.[6]

While the procurement indicated that the RAF was back in the OCA business as the priority placed on supporting Tornado-GR1 strikes indicated, this was very much OCA as part and parcel of a larger wartime effort. As Andrew observed the ALARM had a strong Localised SEAD mandate as the missile was tasked to provide individual aircraft and strike package protection against point defence weapons. Originally the weapon was intended to be used against East German ground-based air defences protecting the eastern side of the Inner German Border. However, this particular role was made redundant following the reunification of the two Germanys and the end of the Cold War in the late 1980s and early 1990s. No sooner had the weapon's foe disappeared than the ALARM and the Tornado-GR1 were deployed to the Middle East to participate in Operation Desert Storm. Andrew continued that during this operation, 120 ALARMs were fired with the majority of these being used to provide Localised SEAD notably to sanitise an air corridor for a strike package.[7] Nevertheless, the lion's share of the SEAD effort performed during Desert Storm was executed by US forces.

As Lambeth noted, in the early 1990s Iraq possessed one of the most sophisticated and lethal IADS in the world. This was equipped with over 16,000 SAMs, and 7,000 AAA guns plus buried command centres and hardened and secure communications links. The opening stages of the war saw the USAF and USN perform SEAD using an array of EF-111A, EA-6B, F-4G Wild Weasel and EC-130H Compass Call communications jamming platforms with a total of

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[6] *Ibid.*
[7] *Ibid.*, pp.101-104.

100 aircraft from the US-led coalition performing SEAD and OCA missions on the first night. Lambeth stated that, at one point during the opening night of air operations on 17 January 1991 over 100 AGM-88B HARM missiles were in flight, the vast majority of which were launched by US platforms. The SEAD element of Desert Storm had a clear Campaign-level goal namely the neutralisation of the Iraqi IADS within the first 24 hours of operations as, understandably, its continued potency would serve as an impediment to wider air operations intended to support the Coalition's aim of evicting the Iraqi armed forces and government from Kuwaiti territory under the terms of United Nations Security Council Resolution 678 which authorised the US-led coalition to use 'all means necessary' to evict Iraq from Kuwait. Lambeth stated that the Coalition achieved the neutralisation of the Iraqi IADS within eight hours of the opening sorties of the war, and although individual SAM batteries would continue to threaten air operations, the neutralisation of the IADS on the first night which had effectively denied its highly centralised nature of both a brain and a nervous system to meaningfully oppose Coalition aircraft, had seen the SEAD effort achieve its Campaign-level objective. Lambeth claimed that the command element of the IADS was destroyed during the first hour of air operations, the communications links networking the system within the first 36 hours, and other GCI centres and hardened SAM installations within the first eight days, with a 95 percent reduction of all Iraqi IADS ground-based air surveillance and FC/GCI radar coverage by day six.[8] It is hard to see how the RAF, despite the deployment of the Tornado-GR1 and ALARM, could have unleashed a similar level of focused destruction on the IADS at anything more than a Localised level. Desert Storm illustrated that since the Second World War, and the intervening years of the Cold War, the RAF's capability of performing SEAD against a similarly matched and sized adversary epitomised by 100 Group had passed to the

[8] B. Lambeth, *The Winning of Air Superiority in Operation Desert Storm*, (Santa Monica: RAND Corporation, 1993), p.2, p.10.

US armed forces as the RAF's posture had changed during the intervening years of the V-force and the need to project air power tactically across the Inner German Border.

It could be argued that, obliquely, the RAF in this context was performing Campaign level SEAD as ALARM attacks against specific ground-based air surveillance and FC/GCI radars supporting the Iraqi IADS were assisting the overall degradation of ground-based air defences and creating increasingly favourable conditions for the coalition. However, the RAF was performing this mission as part of a larger *armada* of aircraft, with the US providing the majority of the SEAD assets and assuming the Campaign level role. RAF assets had demonstrated during the Falklands conflict that Campaign-level SEAD could be performed against an adversary which had deployed a limited quantity of ground-based air defence assets into theatre. Nonetheless it would have been beyond the capabilities of the RAF as it stood in the early 1990s to unilaterally mount Campaign-level SEAD efforts akin to the US against an adversary with an IADS as comprehensive, widespread and well-developed as Iraq's. In many ways the ALARM continued a trend in RAF OCA philosophy witnessed during the years of the V-force: the RAF no longer expected to fight on its own, and would go to war as part of a larger coalition almost certainly involving the US, and it would be the US with her comprehensive SEAD capability forged during the Vietnam War, that would bring the SEAD element to the fight.

The level of SEAD performed by the RAF via the Tornado-GR1 and ALARM combination during Desert Storm became a template for future RAF SEAD efforts in the following years notably in the Balkans, Iraqi and, most recently, Libyan theatres.

This template was exhibited during Operation Deliberate Force, the combined NATO/United Nations air campaign which aimed to undermine the military capability of the Bosnian Serb Army to threaten ‘safe areas’ in Bosnia-Herzegovina. Mounted between 30 August and 20 September 1995, Deliberate Force included a significant SEAD element which rested on attacking SAM, ground-based air surveillance radar and air defence C2 sites that could threaten NATO aircraft over Bosnia-Herzegovina, with most of these targets located on Bosnian Serb held territory. This SEAD effort would be known as Operations Deadeye Southeast and Deadeye Northwest, both of which would later be folded into the wider Deliberate Force air plan to eliminate and degrade the Bosnian Serb Army’s IADS in these two parts of Bosnia-Herzegovina. USAF SEAD assets in the form of the F-16CJ Viper Weasel were in particularly high demand once Deliberate Force commenced on 29 August.[9] US forces brought a significant number of SEAD assets to support the operation. Beyond the F-16CJs, this included F-4G Wild Weasels, EF-111As plus EA-6B Prowlers and Lockheed Martin S-3B Viking aircraft performing EW alongside two EC-130Hs. In total, US forces deployed 22 platforms capable of performing SEAD, the *Luftwaffe* deploying eight Tornado-ECR aircraft equipped with the AGM-88B/C missile, with the RAF deploying no dedicated platforms or weapons to this end, confining its contribution to BAE Systems Harrier-GR7 ground attack aircraft and Tornado-GR1s although with the latter bereft of the ALARM.[10] As Conversino observed, ‘the United States flew 89 percent of Deliberate Force’s 785 SEAD sorties’.[11]

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[9] C. M. Campbell, ‘The Deliberate Force Air Campaign Plan’ in R.C., Owen, ed., *Deliberate Force: A Case Study in Effective Air Campaigning: Final Report of the Air University Balkans Air Campaign Study*, (Maxwell Air Force Base: Air University Press, 2000), p.101, p.111.

[10] M.J. Conversino, ‘Executing Deliberate Force, 30 August-14 September 1995’, in R.C., Owen, ed., *Deliberate Force: A Case Study in Effective Air Campaigning: Final Report of the Air University Balkans Air Campaign Study*, (Maxwell Air Force Base: Air University Press, 2000), p.132.

[11] M.J. Conversino, ‘Executing Deliberate Force, 30 August-14 September 1995’, in R.C., Owen, ed., *Deliberate Force: A Case Study in Effective Air Campaigning: Final Report of the Air University Balkans Air Campaign Study*, (Maxwell Air Force Base: Air University Press, 2000), p.132.

Once again during Operation Allied Force, mounted by NATO between March and June 1999 to end the ethnic cleansing of the Albanian population in Kosovo by the Serbian armed forces and special police units, the majority of the SEAD burden was carried by the US. Like Iraq, Serbia possessed a relatively sophisticated and highly networked IADS, equipped with a wide array of SAMs capable of engaging aircraft from low to high altitudes. In this case, 48 F-16CJ air defence suppression aircraft and EA-6Bs performed the majority of the kinetic and electronic SEAD effort. These were supported by *Luftwaffe* and *Aeronautica Militaire* Tornado-ECR jets equipped with the AGM-88B/C, with EC-130Hs performing the interception and jamming of enemy voice communications, and USAF RC-135V/W aircraft evaluating the success of the SEAD mission in degrading the Serbian IADS' radar and radio communications.[12] The RAF deployed the ALARM as its Localised SEAD contribution to the US-led Campaign level SEAD effort. There appears to be no published information regarding how the RAF employed the ALARM, although it is reasonable to assume that its use mirrored that of Desert Storm, with the missile primarily performing a Localised SEAD mission in support of strike packages ingressing and egressing to and from their targets. As was the case during Desert Storm the RAF was performing the supporting role to the US Campaign level SEAD effort, a trend which would continue during Operation Iraqi Freedom in 2003.

Prior to Iraqi Freedom both the USAF and RAF had been deployed to the Middle East since the end of Operation Desert Storm to enforce northern and southern No Fly Zones over Iraq under Operations Northern Watch and Southern Watch. Both these efforts had witnessed the long-term attrition of the Iraqi IADS particularly in these two areas. In 2002 Operation

[12] Lambeth, 'Kosovo and the Continuing SEAD Challenge'

Southern Watch became Operation Southern Focus which heralded a more proactive degradation of the Iraqi IADS; which encompassed IADS targets between Baghdad and southern Iraq such as ground-based air surveillance radars and communications systems. Thus when Operation Iraqi Freedom commenced on 20 March 2003, a significant quantity of the IADS had already been destroyed as a result of both these previous operations and Desert Storm.[13] As with operations over the Balkans the US deployed the majority of SEAD platforms to contribute to the overall goal of rolling back the Iraqi IADS. These included 60 F-16CJs although the SEAD effort required was relatively minimal. Pirnie observed that, as a result of Operation Southern Watch:

> (C)oalition air forces flew deep into Iraq from the outset of (Operation Iraqi Freedom) without having first to suppress Iraqi air defences. Iraqi air defenders were so weakened and demoralised that they did not attempt to complete radar-guided engagements.[14]

The RAF deployed 30 Tornado-GR4s and the ALARM missile with reports stating that 47 such weapons were fired during the hostilities, although this was dwarfed by the 408 AGM-88B/C missiles launched by US forces.[15] Further, the vast majority of the 2,000 sorties flown against IADS and SAM targets were performed by the US armed forces.[16] Much as before the RAF had played the supporting Localised SEAD role to the larger US-led Campaign SEAD undertaking.

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[13] B.R. Pirnie et al, 'Air Operations', in W. Perry et al, *Operation Iraqi Freedom: Decisive War, Elusive Peace*, (Santa Monica: RAND Corporation, 2015), p.149, p.152.
[14] *Ibid.*, p.152.
[15] 'ALARM' @ https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/ALARM.html (Accessed 16 January 2018) and B.R. Pirnie et al, 'Air Operations', in W. Perry et al, *Operation Iraqi Freedom: Decisive War, Elusive Peace*, (Santa Monica: RAND Corporation, 2015), p.157.
[16] Pirnie et al, 'Air Operations', p.155.

If Iraqi Freedom illustrated the RAF once again performing SEAD at the Localised level, the force's ability to perform SEAD at this level performed its swan song in 2011. That March, a US-led Coalition was again waging a major air campaign, this time as part of Operation Odyssey Dawn/Unified Protector (the operation commenced as a US-led initiative before transitioning to NATO command on 31 March) , mounted to enforce United Nations Security Council Resolutions 1970 and 1973 which imposed sanctions on the regime of Libyan dictator Colonel Muammar Gaddafi, permitted the use of military force to protect Libyan civilians against the regime and established a no-fly zone over the country. From the commencement of operations on 19 March a concerted SEAD campaign against the Libyan IADS was mounted which Wehrey stated neutralised the IADS within twelve days.[17] US forces absorbed the majority of the SEAD burden notably via the employment of USN Boeing EA-18G Growler EW/SEAD platforms, plus F-16CJs and EA-6Bs. SEAD operations would form the initial overtures from the outset to both establish the no-fly zone and to help create increasingly favourable conditions for coalition air operations; both Campaign-level objectives.[18] The RAF did perform missions in support of the OCA effort, primarily delivering air-to-ground ordnance and air-to-surface missiles against ground-based air defence targets, but as Goulter noted the ALARM, which was retired in December 2013, was not used operationally in support of Operation Ellamy; the British contribution to the Libyan operation. The author continued that 'this meant … the RAF became even more dependent upon coalition partners for SEAD'.[19] Whereas the RAF had been relegated to performing Localised SEAD as part of a wider Campaign SEAD effort during previous coalition operations in the

[17] F. Wehrey, 'The Libyan Experience', in K.P. Mueller, ed., *Precision and Purpose: Airpower in the Libyan Civil War* (Santa Monica: RAND Corporation, 2015), p.46.
[18] D.C. Kidwell, 'The US Experience: Operational' in K.P. Mueller, ed., *Precision and Purpose: Airpower in the Libyan Civil War* (Santa Monica: RAND Corporation, 2015), p.119.
[19] C. Goulter, 'The British Experience: Operation Ellamy', in K.P. Mueller, ed., *Precision and Purpose: Airpower in the Libyan Civil War* (Santa Monica: RAND Corporation, 2015), p.160.

Balkans and the Gulf the force was now, for all intents and purposes, out of the SEAD business, instead confined to using standard air-to-ground weaponry in support of the wider OCA effort. A statement from the UK Ministry of Defence announcing the retirement of the ALARM missile confirmed that the RAF would no longer retain the unilateral capability to perform SEAD even at the Localised level: 'It is likely that we will work with our international partners on future major operations overseas and will therefore manage all of our capabilities as part of that coalition.'[20]

The demise of the ALARM marked the end of the RAF's dedicated SEAD capabilities. Certainly the force is capable of using its conventional ordnance to kinetically attack an IADS, but its ability to provide Localised SEAD as it did with the ALARM missile, and as 100 Group and Bomber Command SEAD assets such as 101 Squadron did during the Second World War as part of their wider Campaign-level SEAD effort, is over. In the final analysis, during the Second World War the RAF could perform both Campaign and Localised-level SEAD, reverted to Localised level SEAD during the Cold War and post Cold War eras and now is bereft of any dedicated SEAD capability; wholly dependent on the US to perform Campaign level SEAD and the air forces of the *Luftwaffe* and *Aeronautica Militaire* to perform Localised SEAD with their Tornado-ECRs and accompanying AGM-88 series missiles.

[20] 'RAF retires ALARM missile,' @ http://www.fightercontrol.co.uk/forum/viewtopic.php?f=287&t=92409 consulted 15/1/18.

The Enduring Legacy

Bomber Command's SEAD efforts during the Second World War left a legacy for air power practitioners during the years that followed providing a template for the future execution of Campaign and Localised level SEAD. Not only did 100 Group help to protect Bomber Command through the 18 months of its existence, but the Command's EW efforts in general would pioneer EW principles and SEAD tactics, techniques and procedures which have protected the lives of aircrew ever since. As Addison observed in April 1945:

> When the history of the war is published, and the romantic secrets of radio warfare are revealed, it will be seen how a small and valiant band went out into the dark and dangerous unknown and skilfully and daringly accomplished a mission of which they justly can be proud.[21]

[21] 'The Scape Goats of Bomber Command', AIR 14/2657.

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