Harris’s Scientists: Operational Research in Bomber Command

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Abstract: This essay describes the contents of a unique post-war report, available online through LCMSDS, by the Bomber Command Operational Research Section (ORS) in which the scientists described their mandate, work and contributions to the RAF’s strategic and tactical bombing efforts against Germany. While ORS reports are extensively cited in various histories of the bombing campaign, the processes by which the scientists did their work are not widely known; this essay provides insights into these matters. The essay also gives historical and historiographical context for both reading the report and appreciating the work of Harris’s scientists.

Deep in the Laurier Military History Archive is a unique and amazing document that illuminates the Royal Air Force’s (RAF) bombing campaign against Germany. The Ronnie Shepard Fonds are best known for their material on British Army operational research, but if you access Series 1, the digitised section of the fonds online, you will discover within the Operational Research and Strategic Bombing pages a copy of “Operational Research in Bomber Command,” an extensive post-hostility summary of the origins, role and results of the Bomber Command operational research team.1 The present article will, hopefully, give students of air power, the RAF and military ethics an overview of operational research (OR) in Bomber Command and context for the archival material.

In 1961 Her Majesty’s Stationery Office published the official history of Bomber Command, *The Strategic Air Offensive*. Written by Charles Webster and Noble Frankland, the history is an impressive four volume set that describes in much detail the strategies, campaigns, tactics and technologies which, taken together, cover a span of approximately ten years. Two years later, in 1963, the office of the Air Historical Branch published a relatively unremarkable single volume entitled *The Origin and Development of Operational Research in the RAF*. The link between its 200 pages and the weighty tomes of the official history were and are not immediately obvious, but in the thirty pages that the OR history devoted to Bomber Command the reader got a flavour for the unparalleled challenges that commanders faced and the assistance that the scientists of the Bomber Command Operational Research Section (BC ORS) had provided in finding problems for technical and tactical conundrums. In essence, the Bomber Command chapter was the distillation of an impressive manuscript, titled simply “Operational Research in Bomber Command,” of some 620 foolscap pages which had been prepared by the members of BC ORS in 1945. It is that manuscript which is reproduced in its entirety in the Shepard Fonds and which gives the reader a deep and broad sense of how the scientists and flyers collaborated to bring both efficiency and effectiveness to RAF strategic bombing operations.

This article looks at various aspects of the manuscript and consists of three sections. The first introduces the reader to OR and the context in which it was used in Bomber Command. The second section looks at the structure and content of the manuscript itself. A final section provides some recommendations for further reading as well as a view on the whole question of the RAF’s bombing of Germany.

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2 Sir Charles Webster and Noble Frankland, *The Strategic Air Offensive Against Germany 1939-1945*, vols. 1 to 4 (London: Her Majesty’s Stationery Office, 1961). The ten-year span includes the period before the war when bombing policy and capabilities were being developed.


OPERATIONAL RESEARCH

In the broadest sense, OR has been described as “the use of scientific method in providing executive departments with a quantitative basis for decisions regarding the operations under their control.” In solving problems, scientists and executives do not work in isolation; rather, “[t]he good planner, the good executive with imagination, has to be fully informed about...capabilities and limitations...[And] The good operational research worker will inevitably find himself drawn (given a not too hostile environment) into the planning.”5

During the Second World War, “[p]ast operations were studied to determine facts, theories were elaborated to explain the facts, and finally the facts and theories were used to make predictions about future operations.” Frequently, the value of a quantitative assessment of particular circumstances was in the opportunity to confirm the commander’s intuitive conclusion with statistical analysis.6 Sir Robert Watson-Watt, the British pioneer of radar, saw a role for OR in confirming tactical efficiency. One needed, he said:

to examine quantitatively whether the user organization is getting from the operation of its equipment the best attainable contribution to its overall objective, what are the predominant factors governing the results attained, what changes in equipment or method can be reasonably expected to improve these results at a minimal cost in effort and in time, and the degree to which variations in the tactical objectives are likely to contribute to a more economical and timely attainment of the overall strategic objective.7

Watson-Watt also formulated a short definition of OR stating simply that it sought “maximum effect from available resources.”8

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8 As quoted in Davies and Verhulst, Operational Research in Practice, 2.
OR ACROSS THE RAF

*Operational Research in the RAF* records that the RAF first used operational research during the development and fielding of radar for the air defence of Britain. While scientists such as Watson-Watt focused initially on the technology, the techniques of employing the system were also of fundamental importance and it was in this latter analysis that OR played a central role. So valuable were these and other contributions that, only weeks after the Battle of Britain, Air Chief Marshal Hugh Dowding, Air Officer Commanding-in-Chief (AOC-in-C) of Fighter Command, asked for the first permanent OR section (ORS) to be created in support of his command.9

At Coastal Command, scientists initially attached to those headquarters to study airborne anti-shipping radar also investigated the command’s very low rate of U-boat sinkings. In what is considered among the “classics of operational research” (cited in many OR monographs), the boffins, as scientists generally were called in the RAF, were able to point out that both tactics and weapons were flawed. The resulting changes to depth charge settings and explosives resulted in an increase in sinking of near-surface subs from 2-3 per cent in 1941 to 40 per cent in 1944.10

THE BOMBERS’ PROBLEM

Webster and Frankland wrote that the “operational requirements of a strategic bombing force are easy to express and difficult to attain.” First, a raid had to successfully penetrate enemy defences and navigate to the target area. Then it had to pinpoint and effectively bomb the objective and finally “return to base without suffering more than a bearable casualty rate.” As the two authors further explain: “The bearable casualty rate is a variable and a relative factor which is influenced by the rate of destruction that can be achieved. The greater the rate of destruction, the greater is the casualty rate that can be sustained on each operation, for the fewer

9 Air Ministry, *Operational Research in the RAF*, 3-10.
10 Air Ministry, *Operational Research in the RAF*, 74-77.
will be the number of operations which are required.”\textsuperscript{11} In other words, efficiency—Watson-Watt’s “maximum effect from available resources”—was linked to success.

Initially problems were not recognised. For example, Sir Arthur Harris, who commanded Bomber Command’s No. 5 Group early in the war and was later appointed AOC-in-C of Bomber Command in February 1942, said in his memoirs that there was no reason to suspect the well-trained pre-war crews were not getting to and bombing the target. Only with the introduction of bombing cameras in early 1941 did sufficient evidence finally begin to accumulate to identify “the enormous possibilities of error in navigation by night.”\textsuperscript{12} Thus, in the summer of 1941 the head of the RAF, Sir Charles Portal, a former head of Bomber Command, welcomed an in-depth review of air photos undertaken by the staff of Churchill’s own scientific advisor, Lord Cherwell. The analysis concluded that on nights without clear weather or moonlight, roughly one-third of all aircraft claiming to have attacked their targets actually bombed within five miles of the aiming point; that is, somewhere in a 75 square mile area. When those aircraft that did not claim to have attacked were added to the count, the effective rate was estimated at one-sixth of the potential striking force of the raid.\textsuperscript{13} On 11 September, Portal recommended the establishment of an ORS at Bomber Command Headquarters.\textsuperscript{14}

\textbf{OFFICER IN COMMAND ORS AND HIS MANDATE}

Perhaps coincidentally, Harris’s predecessor, Sir Richard Peirse, had requested the creation of an OR section in August. In defining its mandate, he had said that “[b]roadly speaking, [research should cover] the general study of operations with a view to determining how the efficiency of operations in terms of bombs on target per aircraft lost could be increased.”\textsuperscript{15}

\begin{footnotes}
\item Marshal of the RAF Sir Arthur Harris, *Bomber Offensive* (Toronto: Stoddart, 1947), 80-81.
\item Webster and Frankland, *The Strategic Air Offensive*, vol. 1, 178.
\end{footnotes}
Basil Gordon Dickins, author of *Operational Research in Bomber Command*, photographed by Walter Bird in 1959. Dickins was only 33 when he became head of the Operational Research of Bomber Command [© National Portrait Gallery, London]
Dr. Basil Dickins, since the previous year tasked with producing monthly analyses known as “Report[s] on Losses and Interceptions of Bomber Command Aircraft,” was named section head.\textsuperscript{16} Dickins had received his PhD in 1929 from the Royal College of Science and soon after found employment at Royal Aircraft Establishment Farnborough.\textsuperscript{17} In 1936 he was recruited by Sir Henry Tizard, among the original RAF scientists, to work on the integration of radar into the air defence system (specifically the control of ground-based interceptors).\textsuperscript{18} By 1939, Dickins had been moved to the Maud Project on atomic weapons.\textsuperscript{19} Given the importance of these projects, one gets the sense that Dickins was seen by some of his seniors in the scientific world as an up-and-coming researcher. The official historians seem to confirm this, indicating that: “The appointment of Dr. Dickins as head of the...Operational Research Section of Bomber Command was an event of scarcely less importance than the widespread introduction of night photography.”\textsuperscript{20} In his memoirs, Dickins’s commander, Sir Arthur Harris, refers to Dickins only once, calling him both “brilliant” and “young.”\textsuperscript{21}

**BOMBER HARRIS**

‘Butcher’ Harris, so called because of his apparent indifference to casualties among his crews and German civilians, is often mythologised as the cold, distant bomber baron who would dully throw his crews, attrition style, against the German defences. Critics believe that Harris did not have a quick intellect. “A good case can be made,” historian Max Hastings explains, “that he was slow to grasp the possibilities and limitations of the new generation of radar technology” and that his staff were toadies. In Hastings’s view, “[t]
here appears to have been a chronic lack of open, critical debate... [with] too many weak men and sycophants around the throne.”

A different view was held by Charles Carrington, the army officer assigned to Bomber Command HQ during most of the war. Carrington had served in the Great War alongside Harris’s deputy, Robert Saundby, and was well connected in academic and publishing circles between the wars. Thus, he assessed Harris through the eyes of a contemporary:

‘Bert’ Harris...was the most dominating personality with whom I became acquainted in the Second World War. ... No one doubted that he was a master of his trade and had been so since [the last war]...With his power of concentration on the aim, while excluding the irrelevant, he retained a rugged common-sense...As I came to know him better...I realized that

he was not unco-operative, [and once committed to an idea] even if he opposed its inception, he gave his full support...23

Henry Probert, Harris’s most recent biographer, says that Harris had “an intensively [sic] active and fertile mind eager to leave no stone unturned in the effort to prepare...for the concentrated operations that lay ahead.”24 We might well conclude that, while passionate, Harris would have been open to sound counsel, even that which might have run contrary to intuition or past practice.

“OPERATIONAL RESEARCH IN BOMBER COMMAND” – THE MANUSCRIPT

In his report, Dickins set out to tell several stories, each of them important in their own right for a reader to understand the complex realities of Bomber Command, its headquarters, decision making within the command, the contribution of science and of the scientists, and certainly not least the terrible challenges and risks faced by the crews on every raid. Briefly, the manuscript contains chapters on: the creation, mandate, structure and integration of the section within the headquarters; the collection and analysis of data, including the evolution of techniques over the life of the ORS; the resolution of a range of problems dealing with navigation, target finding and attack; a similar range of problems dealing with the means of identifying the causes of losses and finding ways to reduce them; and finally, a chapter dealing with manpower efficiencies.

Reading through the online document on the Laurier Centre for Military Strategic and Disarmament Studies (LCMSDS) website, the reader will see that the manuscript was clearly a working draft. It is written in a variety of styles, contains ink amendments and lacks specific references for 5 to 10 per cent of its footnotes; these are almost without exception references to specific studies and reports generated by the OR section.

24 Air Commodore Henry Probert, Bomber Harris: His Life and Times (Toronto: Stoddart, 2001), 95.
The document presents the accomplishments of the section in thematic order, dealing with various problems as they were investigated and resolved over the course of the ORS’s term. For the more scientifically minded reader, there is an excellent and lengthy chapter dealing with the processes of qualitative and quantitative analysis, as well as one dealing with the development of the data collection and processing techniques which permitted meaningful and relatively rapid quantitative analysis of operations. Although scientists and technicians associated with the section are identified in the annexes, there is no discussion of personalities or mention of which individuals would have worked on particular issues. Similarly, while there is considerable reference to the process of preparing and publishing reports, there are no samples or actual reports to give a better sense of typical form or format. From the perspective of understanding how the ORS headquarters worked, there are a number of statements concerning the integration of the section into Bomber Command headquarters. While we have only the scientists’ opinions, they concluded that after a period of adaptation they fit in well and were accepted as part of the team. The following paragraphs describe that integration as this working relationship was perhaps as vital as the science itself.

**DOING THE SCIENCE**

In describing the remit of BC ORS, Dickins wrote that the scientists would from time to time receive high priority tasks from their seniors but “normally the items for research originated in the section itself. A detailed research program was prepared and occasionally submitted to the Commander-in-Chief and the Senior Air Staff Officer for approval and guidance as to priorities.”

Initially there was some organisational trial and error, but by early 1942 the ORS had been arranged into three sections: “Research into success of Night Operations; Research into losses in Night Operations; Research into Day Operations.” An ORS 4 was created in mid-1942 with a broad mandate including the extremely important production of the Bomber Command Quarterly Review and the Bomber Command Raid Reports—publications which got important

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new information and findings out to squadrons and crews. Radar and manpower sections were soon added.26 The organisation grew from an initial complement of just seven researchers to fifty-five scientists and ten laboratory assistants by August 1943.27

Chapter Two of the manuscript describes the collection and analysis of data. The placement of this discussion early in the body of the history is significant, for arguably the legitimacy of the section’s conclusions and recommendations had everything to do with the soundness of its collection and interpretation of data. Amassing, sorting and analysing information on both successful and failed raids was a considerable task rendered more difficult by the fact that Bomber Command was involved in a major raid—the equivalent to a land or sea battle—several times a month. As Dickins explains, “[t]he problem is to reconstruct the raid, compare it with the plan, and (if possible) account for major discrepancies between them.”28 Initially, data was insufficient to offer valid conclusions, but by the beginning of 1943 Dickins was satisfied with the sample sizes being achieved and, by later in the year, with the analysis processes.29

There were two types of analyses. Qualitative analysis permitted the rapid estimation of tactical successes or failures and the results were published as soon as possible in ORS reports which were distributed within the headquarters and to the Groups involved. The product of quantitative analysis, on the other hand, was a set of numerical conclusions which were not all that well suited for publication. Yet it was the quantitative data which permitted comparison of different techniques and of the accuracy of attacks under different conditions, while also permitting estimates of “the weight of attack required in future operations.”30

BOFFINS AND BOMBERS

As mentioned, the scientists were not working in isolation, but rather in close contact with the RAF commanders and staff officers

of the headquarters. It was Carrington’s general impression that: “the warriors, generals and marshals, were, in their hearts, a little afraid of these master-minds.”31 Yet aviators like Coastal Command’s AOC-in-C Sir John Slessor and Fighter Command’s AOC-in-C Sir Hugh Dowding were most appreciative of the contribution of their boffins.32 The latter, as he departed from Fighter Command, sent his scientists a note saying: “‘Thanks. This war will be won by science thoughtfully applied to operational needs.’”33

In addition to continuous support from Harris, Dickins indicated a close working relationship between the scientists and the uniformed staff:

It is important to stress that the Section functioned as an integral part of the Command and worked in the closest collaboration with the other branches of the Headquarters. In fact, it is not too much to say that such success as was achieved by the Section was as much due to the receptiveness of the Service as to the efforts of the Scientists.34

Not only did the service staff consider “the incursion of the scientist into the field of operations...an innovation,” but Dickins also remarked that once the scientists had learned the ropes “no proposal made by the O.R.S. was ever turned down by the command on the grounds of impracticability.”35 This was a bit of a stretch as there were a number of conclusions and proposals which were not accepted. Generally, these were not for reasons of poor science; for example, conclusions about the nature of casualties as a result of flak were deemed too sensitive to pass down to the flying units for fear of their impact on morale.

**THE FIRST YEAR**

One of the limitations of the “Operational Research in Bomber Command” manuscript is that the scientists fail to describe the complex nature of parsing useful conclusions from the tangle of factors at play during a raid. The text simply does not allow the reader to see how one set of raids could lead to a range of investigations and recommendations. Nor does the structure of the manuscript give the full sense of the complex interactions between the various tactical and technical problems facing the crews and the Command. The next few pages present a short summary of the ORS’s initial efforts which allows the reader to get some sense of these circumstances.36

Within days of their arrival, the boffins were asked by the AOC-in-C to sort out the causes of poor bombing accuracy, but they were reluctant to do so, stating insufficient and “scanty” evidence.37 By the

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36 For readers that wish to look at the working of the ORS and the headquarters across the whole of the bomber war, see Randall Wakelam, *The Science of Bombing: Operational Research in RAF Bomber Command* (Toronto: University of Toronto Press), 2009.
end of September 1941, however, they were able to make a definite connection between the condition of the moon and a raid’s success. They were still clearly concerned about the reliability of the data, pointing out “the inherent unreliability of crews’ reports and the danger of basing any conclusions as to the success of the attack on these alone.”38 In December, the section concluded a large trial which attempted to gain a better understanding of what crews actually thought they were seeing at night. The scientists gauged from this that there was a “big difference in the reliability of various ground features.” Lakes and rivers, although very popular, had proved to be particularly unreliable, while coastal features including docks were relatively “trustworthy.”39 The boffins’ report was circulated to all command organisations and emphasised the requirement to focus on map-reading skills, both in theory and in practice.40 They were evidently not shy to offer criticism but, as importantly, the

headquarters staff did not shy away from getting scientific views out to the flying stations.

Navigating to the target area and finding the target could both be addressed to some extent, it was generally accepted, by the operational use of the navigation device T.R. 1335, or Gee as it had been dubbed. After the boffins had recommended that research be conducted to find the best means of using Gee, the AOC-in-C “entrusted” the scientists “with the task of drawing up detailed plans for such experiments.” A plan was developed and two experimental attacks, codenamed Cracker, were conducted on 13 and 20 February over the Isle of Man to confirm the soundness of the nascent “Shaker” attack protocol. A Shaker attack consisted of three waves: Gee-equipped “Illuminators” to drop flares, incendiary dropping “Target markers,” and finally the “Followers” to bomb with high explosives. Just days after Harris took command, the procedure was tested during the very successful attack on Renault factory at Billancourt near Paris on 3 March 1942. What is fascinating to note is that it had been the scientists, not the flyers on staff, who were given the task of sorting out the operational use of Gee.

Concentration and the ability to use Gee to actually get the raid to the target had been keys elements in Harris’ big raid on Cologne—the first “1000 raid” on the night of 30 May. Prior to target selection the ORS had done a detailed review of the previous year’s raids and Dickins was called in to brief Harris on their findings. Ralph Barker, author of The Thousand Plan, describes how the scientist went toe-to-toe with his commander. Dickins was firm that the attack should take place within Gee range and repeatedly recommended Cologne, despite Harris’s desire to attack Hamburg which, as a port, Dickins agreed would be easy to find. “At the end Harris said[,] ‘I still want to take on Hamburg.’ ‘Stay within Gee coverage,’ advised Dickins. ‘Go to Cologne.’” The operation order for the raid continued to show Hamburg as the primary target, with Cologne as the alternate, but according to Barker, Harris had actually heard and accepted Dickins

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44 “BC Op Order No 148, dated 26 May 1942,” Air 14/276, TNA. Of note, the attack on Hamburg was planned for 60 minutes (16.7 aircraft per minute for 1000 raiders) while Cologne was scheduled for 90 minutes (11 aircraft per minute).
ORS Plot of Bomb Release Photos for an attack on Berlin in late November 1943. The bombing has been scattered and largely missed the aiming point—the centre of Berlin with its widespread industries and military headquarters. Analysis of every attack was essential in allowing the operational decision makers to adjust tactics and procedures in order to maximize the effect of raids. Detail from ORS B 186 Interim Raid Report on Berlin – 26/27th November, 1943 (H2S Groundmarking), 31 December 1943. [TNA AIR 14/2686]
counsel: “He had come to rely on Dickins’s flair for finding out before a raid what to expect from it.”

Harris wanted the raid to be a big one because, as the boffins had previously concluded, this was the only way to saturate the defences. Yet he remained concerned because there was no prior experience with concentrations of ten or more aircraft per minute. After receiving ORS advice about the minimal chance of collision, he concluded that: “It was obviously much better to accept such a risk, which would mean that two or three aircraft were lost in a really heavy attack, if by doing so we could prevent the loss of 40 or 50 aircraft from night fighters and flak.” In a letter to AOC-in-C Coastal Command he wrote: “the risk of collision is, in my opinion, more than counterbalanced by the complete confusion which will be caused to the enemy’s locator system and gunnery.” As predicted by the boffins, there was only one mid-air collision.

And so it went for three more years, with the scientists providing invaluable findings and recommendations for Harris and his staff to consider and act upon.

**OTHER READINGS**

Several primary and secondary sources make direct or indirect reference to the efforts of the ORS and connect it to other aspects of the war including the development of technologies.

Three official studies should be noted. Previously mentioned, the RAF official history, *The Strategic Air Offensive*, is frank in its assessment of Bomber Command’s performance. It not only describes what went wrong, but also provides explanations, often citing ORS reports, although not by specific report number. Many of the charts depicting specific raids are taken from ORS documents. While not mentioned frequently, the existence and role of the ORS is acknowledged by the official historians. Volume 3 of the Royal Canadian Air Force official history, *The Crucible of War, 1939-1945*, details the participation of the thousands of Canadians who, like other Commonwealth personnel, flew with the RAF during the

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46 Harris, *Bomber Offensive*, 85.
47 Harris to Joubert de la Ferté, letter, 23 June 1942, Air 14/276, TNA.
war.\textsuperscript{48} In Canada’s case, an entire Bomber Command group, No. 6 (RCAF) Group, was formed at the beginning of 1943. Published thirty-three years later, the Canadian history also makes use of ORS documents and charts and acknowledges the scientists. One additional official history mentioned earlier is of note. \textit{The Origins and Development of Operational Research in the Royal Air Force} deals with the impact of operational research across the RAF. The preface states that:

This monograph attempts to trace the origins and development of operational research in the Royal Air Force immediately before and during the last war and to illustrate the characteristic work performed by each of the operational research sections attached to Commands at home and overseas.\textsuperscript{49}

One of Dickins’s scientists has also written on the functioning of the organisation and his perspective is unique. In \textit{Disturbing the Universe}, Freeman Dyson explains some of what he saw, did and thought as a junior scientist in the section.\textsuperscript{50} It is clear from his commentary that he was unhappy with the area bombing policy, with Harris for prosecuting it and with the ORS for not countering the strategy based on research. A similarly critical appraisal of the Command comes from another operational research scientist, Solly Zuckerman, who worked extensively on bombing issues but was never a member of the BC ORS.\textsuperscript{51}

Other useful works focus on the tactical aspects and events of the campaign. For example, Ralph Barker’s \textit{The Thousand Plan: The Story of the First Thousand Bomber Raid on Cologne} examines the planning and execution of the first thousand-bomber raid and uses oral histories from Dickins, Harris and Saundby.\textsuperscript{52} One recent monograph describes the link between operational research, bombing effectiveness and strategic debates. In \textit{The Bomber War: The Allied
Air Offensive Against Nazi Germany, Robin Neillands attempts to
determine why Harris and the Command are so widely criticised.\textsuperscript{53} He compares Bomber Command with the US 8\textsuperscript{th} Air Force, since the
latter claimed to be able to conduct precision bombing. Neillands
wants to see not just what was done by Harris, “but why it was done
and whether, as so often alleged by Harris’s detractors, there was any
other way of doing it at the time” [emphasis in original].\textsuperscript{54} Without
looking at the operational researchers explicitly, he in fact focuses on
the very heart of the challenge facing the senior leaders.

An earlier work, The Six-Year Offensive: Bomber Command in
World War II, by Ken Delve and Peter Jacobs briefly discusses the
role played by the scientists.\textsuperscript{55} Describing the establishment of the OR
section the authors make a number of points, saying that the creation
of an organisation which could look at problems with a scientific
objectivity and then report on them candidly was long past due.\textsuperscript{56} At
the same time, the authors indicate that few outside the Command
headquarters knew of the section’s existence or influence and that the
work of the scientists “has often been ignored by historians.”\textsuperscript{57}

A number of works deal with technologies and their use by
Bomber Command. In Echoes of War: The Story of H2S Radar,
Sir Bernard Lovell tells the story of this airborne radar and its
derivatives.\textsuperscript{58} Michael Cumming’s Beam Bombers: The Secret War
of No. 109 Squadron provides a parallel account of the radio beam
navigation system that was codenamed Oboe.\textsuperscript{59} Gordon Musgrave’s
Pathfinder Force: A History of 8 Group describes the employment

\textsuperscript{53} Robin Neillands, The Bomber War: The Allied Air Offensive Against Nazi
Germany (New York: The Overlook Press, 2001). Several works have examined the
strategic and moral questions which continue to be asked, but do not make reference
to operational research. See, for example, Max Hastings, Bomber Command (New
York: The Dial Press/James Wade, 1979); Denis Richards, The Hardest Victory:
RAF Bomber Command in the Second World War (London: W.W. Norton, 1995);
\textsuperscript{54} Neillands, The Bomber War, 4.
\textsuperscript{55} Ken Delve and Peter Jacobs, The Six-Year Offensive: Bomber Command in World
\textsuperscript{56} Delve and Jacobs, The Six-Year Offensive, 80.
\textsuperscript{57} Delve and Jacobs, The Six-Year Offensive, 129.
\textsuperscript{58} Sir Bernard Lovell, Echoes of War: The Story of H2S Radar (Bristol: Adam
\textsuperscript{59} Michael Cumming, Beam Bombers: The Secret War of No. 109 Squadron (Thrupp,
of these systems so that the reader can get a three-dimensional feel for what took place and was seen by flyers in the night sky.⁶⁰

Similar to these studies of technologies and techniques are those works that examine the application of operational research to resolve difficulties encountered in the field. In 1947 J.G. Crowther and R. Whiddington published Science at War, a small volume designed to tell the story of how scientists contributed to the conduct of the war.⁶¹ Similarly, Ronald Clark’s 1962 The Rise of the Boffins was the product of a desire to describe “the scientists’ war.”⁶² Two more recent writings provide examinations of operational research in support of the British war effort. Joseph F. McCloskey’s “British Operational Research in World War II” is brief, but still detailed enough to make clear the main constituents of operational research in all three British services.⁶³ More comprehensive, but less focussed, is Maurice Kirby’s Operational Research in War and Peace: The British Experience from the 1930s to 1970.⁶⁴

SOME CONCLUDING THOUGHTS – DID OPERATIONAL RESEARCH INFLUENCE DECISIONS AND SO WHAT?

The existing discourse on Sir Arthur Harris and Bomber Command tells us much about the bombing campaign. But what we do not yet adequately understand is how Harris came to make his tactical and technical decisions, the decisions that affected the day-to-day efficiency and effectiveness of operations and that ultimately made his operational goals attainable.

⁶⁴ Maurice W. Kirby, Operational Research in War and Peace: The British Experience from the 1930s to 1970 (London: Imperial College Press, 2003).
From the ORS manuscript we can see clearly that while Harris was undoubtedly the decision maker, at the same time he had access to and accepted the advice of his operational research staff. Indeed, Harris was certainly effusive about his boffins: “An Operational Research Section is indispensable...[and] the work of the large research section of my Command saved thousands of lives and hundreds of aircraft.”65 He might have added that it rendered the work of the Command more effective and efficient at the same time.

So what? Reading this manuscript gives a sense of the complex, ambiguous and often chaotic circumstances of the bomber war and the challenges that Harris and other commanders faced. That they were aided in quantifying and qualifying these difficulties and in developing solutions that could be practically applied speaks much to the value of science and the hard work and dedication of Harris’s scientists.

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ABOUT THE AUTHOR

After graduating from RMC in 1975, Randall Wakelam flew helicopters for the army, becoming CO of 408 Squadron in 1991. In 1993 he became an educator, first in uniform at the Canadian Forces College in Toronto and Canadian Defence Academy, and beginning in 2009 as civilian faculty at RMC where he taught History and War Studies courses and twice ran the Writing Centre before retiring in 2019. Wakelam completed the Land Forces Command and Staff Course in 1979 and the CF Command and Staff Course in 1988. He has a BA and MA from RMC, the latter in War Studies, and a PhD in History from Wilfrid Laurier University. Wakelam writes in the fields of air power, leadership and military education.

65 Harris, *Bomber Offensive*, 201.