"Solving of Conundrums:" Operational Research and The Royal Regiment of Canadian Artillery

By: Monty's Scientists

Reflecting on his time as the Scientific Advisor to the Commander-in-Chief (C-in-C) 21st Army Group during the Second World War, Brigadier Basil Schonland noted:

> [T]he great thing the [No. 2] ORS [Operational Research Section] did was to show that an operational research section have as their first duty the rapid application of lessons learned from operations and they are able to derive such lessons in a form which will carry conviction. Every C-in-C and his Chief of Staff in a future campaign should be given a copy of *Operational Research in Northwest Europe*.[1]

Through the "solving of conundrums," as Schonland put it, he and his team had brought their scientific methodologies to bear on the art of war and positively contributed to the success of Field Marshal Viscount Montgomery and the 21st Army Group in Northwest Europe.[2] Operational research (OR) solves problems and supports decisions with science. In a military context, OR is useful for both measuring effectiveness as well as performance. OR tells commanders if they are doing the right things to create desired effects and determines if they are doing those activities right.[3] Both questions need to be consistently satisfied with an effects-based approach to operations (EBAO). Given the Canadian Army's doctrinal subscription to EBAO, an examination of how commanders and staffs exploited OR during the First and Second World Wars to improve the effectiveness of their fires is necessary to determine how the present-day Royal Regiment of Canadian Artillery (RCA) can benefit from reengaging with this discipline.

The RCA and OR are intimately connected. Indeed, General Andrew McNaughton, one of Canada's greatest gunners and the commander of the First Canadian Army during the Second World War, was the first practitioner of army OR during the First World War. The scientific work done by McNaughton and his staff enabled the Canadian Corps to become highly proficient at counter-battery fire. The Canadian artillery again benefited from OR during the Second World War. The scientists of No. 2 ORS, integral to the 21st Army Group, examined several issues related to fires, including the effectiveness of offshore bombardment by self-propelled guns on D-Day, counter-mortar operations, and the impact of close air support (CAS). Despite the importance of OR to land operations, most of the literature focuses on the role it played in the development of radar in Britain during the interwar years and Bomber Command's strategic bombing offensive against Germany.[4] With the notable exception of

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[1] Imperial War Museum, Papers of Field Marshal Viscount Montgomery, BLM 140/6, B.J.F. Schonland, "On Being a Scientific Advisor to a Commander-in-Chief," 10.

[2] Quoted in Terry Copp, "Scientists and the Art of War: Operational Research in 21 Army Group," *The RUSI Journal* Vol. 136, no. 4 (Winter 1991): 66.

[3] Department of National Defence, B-GL-300-001/FP-001, *Land Operations* (Ottawa: Chief of the Land Staff, 2008), 5-37 – 5-40.

[4] In addition to "Scientists and the Art of War," Copp's works include: Terry Copp, "Operational Research and 21 Army Group," *Canadian Military History* Vol. 3, no. 1 (1994): 71-84; Terry Copp, "Counter-Mortar Operational Research in 21 Army Group," *Canadian Military History* Vol. 3, no. 2 (1994): 45-52; and Terry Copp, ed., *Montgomery' Scientists: Operational Research in Northwest Europe – The Work of No. 2 Operational Research Section with 21 Army Group, June 1944 to July 1945* (Waterloo: Wilfrid Laurier University, 2000).

the work done by historian Terry Copp, there has been little written about army OR.[5] The lack of literature is somewhat surprising since both Field Marshal Sir Douglas Haig, C-in-C British Expeditionary Force (BEF), and Montgomery understood the crucial role of science on the battlefield and sought to fully exploit this intellectual advantage over their enemies to achieve their end states.

Creating the effects that contribute towards achieving that end state is the essence of EBAO. These effects are not only munitions based.

> In the […] effects-based contest, the objective is to break the will or otherwise shape the behaviour of the enemy so that he no longer retains the will to fight, or to so disorient him that he can no longer fight or react coherently. Although physical destruction remains a factor in EBO [effects-based operations], it is the creation of such a psychological or cogitative effect that is the primary focus of the effects-based approach.[6]

Neither Haig nor Monty ever referred to the modern concept of EBAO, but they knew that armies fought on both the physical and moral planes. Haig continued several offensives like the Somme and Passchendaele long after they had bogged down since he had misplaced confidence in intelligence assessments that indicated the morale of German forces was near the breaking point.[7] Like Haig, Monty sought to maintain the morale of his troops, but Montgomery also had to contend with a severe British manpower shortage and had to keep his casualties as low as possible.[8] Montgomery understood that his 21st Army Group was a wasting asset that could not be reconstituted if it was wrecked fighting the German army. Both Haig and Montgomery's forces employed fires to create both moral and physical effects, and OR optimized the effectiveness of their artillery to deliver these effects.

The artillery dominated the battlefield during the First World War, and attacks launched without first neutralizing the enemy's guns were almost certain to fail. The offensives launched by the BEF in 1915 and 1916 had demonstrated that. The British army devoted much effort and talent to winning the counter-battery fight from 1917 until the end of the war. The BEF created a new section in corps headquarters – the counter-battery staff office – and sought out civilian experts in physics and mathematics to improve its flash-spotting and sound-ranging techniques.[9] Perhaps intuitive now, bringing in civilian OR scientists to enhance the army's equipment and TTPs was unprecedented before the First World War. Haig wrote:

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[5] Joseph F. McCloskey, "The Beginnings of Operations Research: 1934-1941," *Operations Research* Vol. 35, no. 1 (January-February 1987): 143-152; Joseph F. McCloskey, "British Operational Research in World War II," *Operations Research* Vol. 35, no. 3 (May-June 1987): 453-470; Maurice W. Kirby, *Operational Research in War and Peace: The British Experience from the 1930s to 1970* (London: Imperial College Press, 2003); and Randall T. Wakelam, *The Science of Bombing: Operational Research in RAF Bomber Command* (Toronto, Buffalo, London: University of Toronto Press: 2009).

[6] United States Department of Defense, *Military Transformation: A Strategic Approach* (Washington: Director Force Transformation, Office of the Secretary of Dense, 2003), 36.

[7] Gary Sheffield, *The Chief: Douglas Haig and the British Army* (London: Aurum, 2011), 373-374.

[8] Stephen Ashley Hart, *Colossal Cracks: Montgomery's 21st Army Group in Northwest Europe, 1944-45* (Mechanicsburg: Stackpole Books, 2007), 20-68.

[9] Albert P. Palazzo, "The British Army's Counter-Battery Staff Office and Control of the Enemy in World War I," *The Journal of Military History* Vol. 63, no. 1 (January 1999): 55-74.

> The general superiority of the Allies in this direction [counter-battery] during the concluding stages of the recent struggle undoubtedly contributed powerfully to their success. In this respect the Army owes a great debt to science, and to the distinguished scientific men who placed their learning and skill at the disposal of their country.[10]

Despite Haig's appreciation for these scientists, not all of his generals fully understood the need for innovation on the battlefield. After observing a flash-spotting demonstration, one British general purportedly told Colonel Harold Hemming, a Canadian officer serving with the British Third Army, that "You take all the fun out of war."[11] The Canadian Corps, however, did, and its success during the Battle of Vimy Ridge (9-12 April 1917) owed much to the OR done by then Lieutenant-Colonel Andrew McNaughton and his counter-battery staff to determine the location of German guns and neutralize them before launching the attack.[12]

An electrical engineer at McGill University before the war, McNaughton readily accepted that OR could improve the effectiveness of the artillery in the Canadian Corps. McNaughton sought out the services of three scientists: Lawrence Bragg, a British physicist and winner of the Nobel Prize in 1915, Charles Darwin, a physicist and the grandson of the famous naturalist, and Lucien Bell, the inventor of the oscillograph, who had wandered across the various British formations on the Western Front looking for work.[13] The improvements that these men made to the sound-ranging and flash-spotting techniques used by the Canadian Corps paid off. When the battle began, the Canadian artillery had neutralized 83 percent of the German guns at Vimy.[14] Besides the physical effect of having their pieces destroyed, the moral impact of the loss of their integral artillery and the sustained bombardment resulted in an almost complete breakdown of German command and control.[15] Still, Vimy was no easy fight, and the Canadian Corps sustained 10,602 casualties seizing the ridge.[16] However, the losses would have been much higher, and the Germans might have been able to repel the Canadian attack if they could have used more than 17 percent of their artillery. Under McNaughton, the counter-battery staff office continued to innovate. One of its greatest feats occurred after the Battle of Hill 70 (15-25 August 1917). The RCA destroyed a 38-cm German railway gun near Lens through sound-ranging, despite the best efforts of the German gunners to move the piece back to its concrete emplacement after firing and mask its muzzle flash by firing other smaller pieces to deceive British flash spotters.[17] Neutralizing the German artillery

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[10] J.H. Boraston, ed., *Sir Douglas Haig's Despatches, December 1915- April 1919* (London and Toronto: J.M. Dent & Sons Ltd., 1919) 329.
[11] Pierre Berton, *Vimy* (Toronto: McClelland and Stewart, 1986), 164.
[12] J.S. Finan and W.J. Hurley, "McNaughton and Canadian Operational Research at Vimy," *Journal of the Operational Research Society* Vol. 48, no. 1 (January 1997): 10-14; and Paul Dickson, "Leadership and Innovation: Andrew McNaughton and the Counter-Battery Staff Office," in *Great War Commands: Historical Perspectives on Canadian Army Leadership, 1914-1918*, ed. Andrew B. Godfrey (Kingston: Canadian Defence Academy Press, 2010), 145-166.
[13] John Swettenham, *McNaughton: Volume 1, 1887-1939* (Toronto: The Ryerson Press, 1968), 77.
[14] Finan and Hurley, "McNaughton and Canadian Operational Research at Vimy," 13.
[15] Andrew Godefroy, "The German Army at Vimy Ridge," in *Vimy Ridge: A Canadian Reassessment*, eds. Geoffrey Hayes, Andrew Iarocci, and Mike Bechthold (Waterloo: Wilfred Laurier University Press, 2014), 230.
[16] G.W.L. Nicholson, *Canadian Expeditionary Force, 1914-1919: Official History of the Canadian Army in the First World War* (Montreal, Kingston, London, and Chicago: McGill-Queen's University Press, 2015), 265.
[17] G.W.L. Nicholson, *The Gunners of Canada: The History of the Royal Regiment of Canadian Artillery, Volume I, 1634-1919* (Toronto and Montreal: McClelland and Stewart Limited, 1967), 314-315.

crippled the German army's ability to resist Allied attacks and played a significant role in the Allied success on the Western Front.

For OR to be meaningful, the audience must be receptive, and the chain of command must support the work of the OR scientists. Despite the many criticisms levelled against him, Haig supported innovation, particularly in the artillery. He reflected:

> Four years of scientific warfare have seen a consistent and progressive development in the power and influence of artillery […] Despite the handicap under which we started the war, British artillery has played a large part in that development and of late has dominated the enemy's artillery to an ever-increasing degree. The influence of this fact upon the moral both of our own and the enemy's troops could scarcely be exaggerated.[18]

Being a soldier-scientist, McNaughton advocated for scientific development within the artillery, but he was only able to accomplish so much since he worked in an organization that was receptive to innovation.[19] Lieutenant-General Sir Arthur Currie, the commander of the Canadian Corps, and Major-General Sir E.W.B. Morrison, the general officer commanding Royal Artillery, both supported McNaughton and his innovative methods.[20] This likely explains the exceptional effectiveness of the Canadian Corps at counter-battery work compared to other British corps that did not have supportive commanders and staffs.[21] During the Second World War, OR scientists attached to the Eighth Army in North Africa and Italy had most of their work fall on deaf ears. The seasoned veterans of the desert were more apt to trust their experience and judgement than listen to statistics. One researched recalled, "A new type of unit has great difficulty in making good headway unless it is lucky enough to have a powerful sponsor. In No. 1 ORS' case there was no such person and work was undertaken in a somewhat haphazard manner."[22] No. 1 ORS produced fifteen reports during the Italian campaign. Of these reports, twelve examined with the accuracy and effectiveness of artillery fire; however, the Eighth Army chain of command took little interest in their work.[23] Fortunately, the RCA regiments fighting in Northwest Europe had a more positive experience with OR.

In the 21st Army Group, Montgomery had a scientific advisor and a robust OR Section in his staff. Monty's Chief of Staff, Major-General Sir Francis de Guingand, assigned No. 2 ORS several problems to investigate and fully exploited the potential of this unit. Unlike their First World War predecessors, these scientists were all in the military. Their inclusion in the army group headquarters and Montgomery's directive command style ensured that any recommendations made by No. 2 ORS, with his concurrence, were sure to be adopted across the units in First Canadian Army and British Second Army. One of his scientists wrote:

> Seeing whether these operations actually yield the results expected from them should be a matter of direct scientific analysis. The ultimate answer is provided by victory or defeat, but failure to understand that factors contributing to that victory or defeat, and

[18] Boraston, *Sir Douglas Haig's Despatches*, 300.
[19] Dickson, "Leadership and Innovation," 151-152; and Nicholson, *The Gunners of Canada*, 315.
[20] Swettenham, *McNaughton*, 67, 74-75.
[21] Finan and Hurley, "McNaughton and Canadian Operational Research at Vimy," 12.
[22] Copp, "Operational Research and 21st Army Group," 73.
[23] Copp, "Scientists and the Art of War," 66.

> the degree to which each contributes, removes any secure ground for organizing further success.[24]

OR provided Monty with an objective means to assess the effectiveness of his operations and to determine if he was optimally employing his forces to achieve the effects he wanted.

The work of No. 2 ORS began almost immediately after D-Day. To augment the fire plan on Juno Beach, four field regiments of self-propelled guns engaged the German defences from landing craft.[25] Despite the technical complexities of this shoot and early reports that the bombardment was effective, the examination by Major John Fairlie, a Canadian gunner in No. 2 ORS, proved otherwise. His report noted that "No serious damage was done to any of the defences by SP fire."[26] Fairlie further writes, "The defences were overcome by DD tanks, engineer, and infantry assault … [T]he defences were substantially intact when the infantry touched down and the enemy were able to deliver lethal fire in great quantity against our troops."[27] The gunners of the 3rd Canadian Infantry Division may not have been pleased by this report, but the information could be used by planners for future amphibious assaults to avoid employing the guns in a way that did not create the desired effects. Similarly, when questions about whether the function of the 25-pounder was primarily anti-personnel or anti-materiel, the ORS produced a report recommending that the gun be employed as an anti-personnel weapon to deliver both lethal and morale effects.[28] Seemingly, the recommendation worked. In *The Guns of Normandy*, George Blackburn writes that Germans prisoners of war being taken rearward asked to see the "automatic 25-pounder" since they refused to believe that a gun that required each round to be loaded by hand could put down such a high rate of fire.[29]

Montgomery's scientists also had an important role in developing counter-mortar operations and improving the effectiveness of CAS. Not only did German mortars cause the majority of Allied casualties in Normandy, they also greatly demoralized Allied infantrymen.[30] Worse yet, each German infantry division had between forty to eighty mortars, mostly 81-mm with some 120-mm, and fifty *Nebelwerfers*, six-barrelled launchers.[31] The Canadian divisional artillery needed to be able to locate the tubes and launchers and assign a regiment of 25-pounders to prosecute them. Although crater analysis was the preferred method of determining the location of the enemy mortars, hazardous battlefield conditions made it impractical to probe the craters made by the mortar bombs.[32] In his report, Major Mike Swann suggested that radar might also be used to help the field artillery locate German mortars.[33] The slow, high parabolic trajectories of mortars enabled radar to track the bombs and determine the

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[24] Copp, "Operational Research and 21st Army Group," 71.
[25] C.P. Stacey, *Official History of The Canadian Army in the Second World War, Volume III – The Victory Campaign: The Operations in North-West Europe, 1944-1945* (Ottawa: Queen's Printer and Controller of Stationery, 1960), 98-99.
[26] Copp, "Report No. 1, Self-Propelled Artillery in the Assault on the Beaches – 3rd Canadian Infantry Division Sector," in *Montgomery's Scientists*, 379.
[27] Ibid, 385.
[28] Kirby, *Operational Research in War and Peace*, 120.
[29] George G. Blackburn, *The Guns of Normandy: A Soldier's Eye View, France 1944* (Toronto: McClelland & Stewart, 1995), 346.
[30] Copp, "Counter-Mortar Operational Research in 21 Army Group," 45.
[31] Copp, "Report No. 11, The Location of Enemy Mortars," in *Montgomery's Scientists*, 437.
[32] Copp, "Counter-Mortar Operational Research in 21 Army Group," 49.
[33] Copp, "Report No. 11," 435-436, 438-439.

location of the launcher.[34] The artillery applied this recommendation, and used radar to detect German mortars during Operation VERITABLE (8 February – 11 March 1945).[35] No. 2 ORS also examined the effectiveness of CAS in Normandy. 21st Army Group regularly employed CAS, with platforms varying from Typhon fighter-bombers to strategic heavy bombers, to support its operations. The examination of the claims made by Second Tactical Air Force Typhoon pilots that they destroyed eighty-nine tanks, fifty-six tracked vehicles, and 151 motor vehicles, with an additional fifty-six tanks and eighty-one trucks damaged on the Mortain battlefield, made some interesting discoveries.[36] The researchers determined that only forty-seven tanks had been destroyed – *seven* by aircraft rockets – and thirty trucks.[37] The report also discounted the claim made by the air force that German recovery salvaged the majority of the destroyed vehicles and noted that the moral effect of aerial attack caused more crews to abandon their vehicles than were destroyed by Allied munitions.[38] The reports on the employment of heavy bombers to support ground operations also determined that the moral effects greatly exceeded any physical effects against the German forces; however, the aerial bombardment had to be quickly followed by an attack with ground forces to have any lasting effects.[39]

It is unlikely that Canada will ever again be involved in a global conflict on the scale of the First and Second World Wars. However, we would be remiss to ignore the lessons learned by our predecessors. Schonland and his team of operational researchers had contributed to the success of the Northwest Europe campaign through the "solving of conundrums." They analyzed military problems with scientific rigour to make recommendations that would improve the effectiveness of British fires. These scientists expanded upon the foundation laid by McNaughton and his counter-battery team of using OR to optimize effects. Although Schonland argued that any future commander would be heedless to ignore OR, it seems that the Canadian Army has done just that. OR has all but disappeared from the tactical and operational levels of war for the Canadian Army. Presently in the Canadian Armed Forces, OR is conducted at the strategic level by Defence Research and Development Canada, Centre for Operational Research and Analysis and at the operational level by the Canadian Joint Operations Commander Operational Research Team. Both organizations are rather small, and the demands placed upon them outstrip their human and financial resources.[40] We have essentially come full circle. Any commander seeking an answer to a tactical or operational problem would have to reach out to one of these organizations and hope to get a reply. In the meantime, commanders and staffs are left relying on anecdotal evidence or out of date data to assess their measures of effectiveness and measures of performance. The examination of the history of OR and the RCA in both World Wars underscores the

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[34] George Lindsey, "Some Personal Recollections of Army Operations Research on Radar in World War II," *Canadian Military History* Vol. 4, no. 2 (Autumn 1995): 69-74.
[35] Stacey, *The Victory Campaign*, 467-470.
[36] Copp, "Scientists and the Art of War," 67.
[37] Copp, "Report No. 4, Air Attacks on Enemy Tanks and Motor Transport in the Mortain Area, August 1944," in *Montgomery's Scientists*, 175.
[38] Ibid, 175-176.
[39] Copp, "Report No. 14, Heavy Bombing in Support of the Army," in *Montgomery's Scientists*, 99-106.
[40] Thierry Gongora and Ben Taylor, *Defence Research and Development Canada (DRDC) – Centre for Operational Research and Analysis (CORA) Science and Technology (S&T) Capability Assessment: Documenting the Method and Results of the 2017 Assessment* (Ottawa: Department of National Defence, 2019), http://cradpdf.drdc-rddc.gc.ca/PDFS/unc339/p810127_A1b.pdf; and Mark Rempel, *A Strategic Review of the CJOC OR&A Work Program* (Ottawa: Department of National Defence, 2018) http://cradpdf.drdc-rddc.gc.ca/PDFS/unc325/p807806_A1b.pdf.

necessity for scientists to conduct OR at the tactical and operational levels of war. The Canadian Army and The Royal Regiment would be well served by reviving this capability.