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Heavy Armour and the Evolution of the Royal Canadian Armoured Corps

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Heavy Armour and the Evolution of the Royal Canadian Armoured Corps

HEAVY ARMOUR AND THE EVOLUTION OF THE ROYAL CANADIAN ARMOURED CORPS

INTRODUCTION

On a cold winter morning on the 24th of February 2022, Russian forces crossed into the Ukraine and began their advance towards the capital Kyiv.[1] The Russian attack encountered stiff resistance from the Ukrainian infantry armed with relatively inexpensive Anti-Tank Guided Missiles (ATGM) from America, Sweden and Germany. As of 24 April 2022, Russia had reportedly lost 551 Main Battle Tanks (MBT) either damaged, abandoned, captured or destroyed.[2] These devastating losses halted the initial spearhead of the Russian invasion and forced Russian planners to re-examine their approach and overall strategic objectives. The once formidable Russian tank army had been handed defeat by a determined foe armed with lightweight infantry portable ATGMs.[3]

Modern armoured forces draw much of their historical legacy from horse borne cavalry units, which at their core provided battlefield commanders the ability to move combat power rapidly across the battlefield. Cavalry utilized their speed and violence to gather intelligence, close with and break the enemy, exploit opportunities and disrupt enemy plans. The wars of the early 20th century saw a sharp decline in the use of horse borne cavalry due to the evolution of static trench warfare, and the machine gun which effectively countered the cavalry's mobility and combat effectiveness. The introduction of

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[1] Tim Lister CNN Tara John and Paul P. Murphy, "Here's What We Know about How Russia's Invasion of Ukraine Unfolded," CNN, accessed April 24, 2022, https://www.cnn.com/2022/02/24/europe/ukraine-russia-attack-timeline-intl/index.html.

[2] Oryx, "Attack On Europe: Documenting Russian Equipment Losses During The 2022 Russian Invasion Of Ukraine," *Oryx* (blog), accessed April 24, 2022, https://www.oryxspioenkop.com/2022/02/attack-on-europe-documenting-equipment.html.

[3] Michael Lee, "Drones and Missiles: The Weapons Making a Difference in Ukraine," *CTV News*, March 16, 2022, sec. World, https://www.ctvnews.ca/world/drones-and-missiles-the-weapons-making-a-difference-in-ukraine-1.5821581.

the slow but heavily armoured tank provided a solution to this mobility issue by drastically increasing the crew's survivability. The invention of the tank had managed to combine the protection role of a siege tower as well as the lethal effects of the cavalry.[4]

The battle in the Ukraine has highlighted a natural turning point in the development of armour, such that the axiom of, "… more armour equals better protection…" has been overturned.[5] In the same way that medieval armour lost relevance due to the increasing lethality of firearms, and battleships lost relevance due to the increasing lethality of guided weapons; the heavily armoured tank is losing its relevance due to the proliferation of effective and low-cost armour defeating weapons.[6]

The Royal Canadian Armoured Corps (RCAC) has recently adopted an Armoured Cavalry employment concept and is in the process of adapting its training and doctrine to align. Definitions such as Armour-Heavy and Armour-Reconnaissance are being re-examined through the Armoured Cavalry lens to ensure RCAC forces are properly employed by operational commanders in a manner that can cover all assigned tasks within the "Spectrum of Armour".[7] The Canadian Army's (CA) recent procurement of the TAPV (Tactical Armoured Patrol Vehicle) has generally been shunned by most Arms as unfit for purpose.[8] When the questionable TAPV procurement is combined with the 2013 cancellation of the Close Combatant Vehicle (CCV) program, it becomes apparent that the CA is at a crossroads when it comes to defining requirements for Armoured Fighting

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[4] Jeremy Black, *Tank Warfare* (Bloomington, Indiana: Indiana University Press, 2020), 22.

[5] Gareth Evans, "What Does the Future Hold for Tanks?," *Army-Technology.Com*, January 2, 2017, https://www.army-technology.com/features/featurewhat-does-the-future-hold-for-tanks-5688047/.

[6] "The Future of Armoured Warfare: 'Fly Light, Die Early'?," *Strategic Comments* 4, no. 8 (October 1998): 2.

[7] Colonel Dove, R.D., "Armoured Cavalry: Cavalry By Heritage - Cavalry By Culture - Cavalry By Design," in *RCAC Update to ATA / CADTC* (Gagetown, NB: Director Armour, 2022).

[8] Vladimir Kessia, "The Role of Armoured Reconnaissance Within the Canadian Army," *Canadian Military Journal* 22, no. 2 (Spring 2022): 1.

Vehicles (AFV) and with it, the role that the RCAC plays on the battlefield.[9] "The key to the future of armored warfare lies in disregarding what we expect a tank to be in order to focus on what we need the tank of the future to do."[10]

This paper will establish that heavy AFV are less relevant to the CA due to the effectiveness of modern armour defeating weapons, the RCAC role change to Armoured Cavalry, and the developments of alternate technologies available to increase AFV survivability.

STRIKERS VS SHIELDERS

Since the advent of the tank during the First World War, the concept of armoured protection has been a dominant factor in driving design decisions in mechanized warfare.[11] "More armor equaled more protection".[12] This has resulted in progressively more armour protection and consequently heavier AFV. Over the remainder of the nineteenth century the tank continued to evolve in mobility, armour protection and lethality. A natural competition ensued between the increasing lethality of weaponry versus armours ability to protect vehicle crews from damage and stay in the fight.[13]

Modern heavy tanks have been able to achieve significant levels of protection at

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[9] James Cudmore, "Government Won't Buy New $2B Armoured Vehicles for Army," *CBC News*, December 19, 2013, https://www.cbc.ca/news/politics/government-won-t-buy-new-2b-armoured-vehicles-for-army-1.2470689.

[10] Ralph Peters, *Fighting for the Future: Will America Triumph?*, 1st ed (Mechanicsburg, PA: Stackpole Books, 1999), 44.

[11] Donncha Lenihan et al., "A Review of the Integrity of Metallic Vehicle Armour to Projectile Attack," *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications* 233, no. 1 (January 1, 2019): 73, https://doi.org/10.1177/1464420718759704.

[12] DARPA, "Ground X-Vehicle Technologies," Ground X-Vehicle Technologies (GXV-T), accessed April 24, 2022, https://www.darpa.mil/program/ground-x-vehicle-technologies.

[13] John Amble, "How Will Technology Change Future Wars?," MWI Podcast:, accessed March 25, 2022, https://mwi.usma.edu/mwi-podcast-will-technology-change-future-wars/.

the expense of weight, mobility and speed.[14] This performance trade-off was rational when a commander could expect high vehicle survivability to offset this loss of speed and mobility. Developments in armour defeating weapons such as ATGM's has long been predicted as eventually being able to defeat heavily armoured platforms. In 1998 the International Institute for Strategic Studies identified that the increasing lethality of projectiles "… may at some point make conventional armoured protection so heavy that it becomes impractical".[15] What the high number of tank kills coming from the conflict in Ukraine has underscored, is that the survivability equation has been tipped. The lethality of low-cost and lightweight weapons such as ATGMs now outmatch the heavy armour protection provided by the MBT.[16]

It should be noted that the tank still provides a good level of protection to its crew against some munitions, however, the imbalance between the cost of a tank versus the cost to defeat it is significant. The purchase cost of a German manufactured Leopard 2A6 MBT has been estimated to be in the range of $7 million United States (US) dollars.[17] In contrast, the US manufactured FGM-148 Javelin ATGM has been reported by CNBC to cost $176,000 US dollars.[18] The cost of a MBT is thirty-five times the cost of an ATGM. The Javelin has a range of up to 2.5 kilometres and can destroy or disable a tank with a

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[14] Evans, "What Does the Future Hold for Tanks?"

[15] "The Future of Armoured Warfare," 2.

[16] "How Tanks Can Survive against Cheap, Shoulder-Fired Missiles," *The Economist*, April 2, 2022, https://www.economist.com/science-and-technology/2022/04/02/how-tanks-can-survive-against-cheap-shoulder-fired-missiles.

[17] "Battle Tank Cost - in 2022 - The Pricer," March 24, 2022, https://www.thepricer.org/battle-tank-cost/.

[18] Brad Howard, "How This U.S.-Made, $176,000 Anti-Tank Weapon Could Change the War in Ukraine," *CNBC*, April 29, 2022, sec. Defense, https://www.cnbc.com/2022/04/29/how-this-us-made-176000-anti-tank-weapon-could-change-the-war-in-ukraine.html.

single round.[19] While tank cannon ammunition is also relatively inexpensive when compared to the cost of a MBT, it still requires a medium to heavy AFV platform to transport the weight of the cannon, turret and ammunition into battle. The modern ATGM is carried into battle on the backs of infantry, or carried in a pick-up truck. As such, the cost of transporting the same lethality of weapon onto the battlefield is not comparable between a tank round and the cost of an ATGM. When the high cost of the tank is contrasted against the low cost to defeat its armour protection and render it combat ineffective, it becomes clear that the relevance of heavy armour as a requirement for future AFV selection is diminished.

The issue of heavy armour relevance was recently tackled by the US Marine Corps (USMC) which, in 2020 began the process of divesting itself of tanks. US Lieutenant General Eric Smith justified the USMC reason for the move away from tanks as, "We [USMC] can kill armor formations at longer ranges using additional and other resources without incurring a 74-ton challenge …".[20] The marine corps experiments had identified that, "They were seeing armor kills using lightweight mounted fires from the joint light tactical vehicle at ranges of 15 times to 20 times the distance a tank was previously achieving."[21] The USMC had deduced that they were able to deliver overwhelming firepower mounted on light platforms which could destroy heavily armoured tanks more effectively than with another tank. The secondary deduction that

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[19] Jane's Group UK Limited, "FGM-148D Explorer," Janes, accessed May 27, 2022, https://customer-janes-com.cfc.idm.oclc.org/explorer/Equipment_92938?bc=04b29859-cda1-4e23-84bb-2d0e4fba6694&explorerState=61fd8a51-c06f-4092-900e-5411d69b8258.

[20] Todd South, "Goodbye, Tanks: How the Marine Corps Will Change, and What It Will Lose, by Ditching Its Armor," Marine Corps Times, March 22, 2021, https://www.marinecorpstimes.com/news/your-marine-corps/2021/03/22/goodbye-tanks-how-the-marine-corps-will-change-and-what-it-will-lose-by-ditching-its-armor/.

[21] Ibid.

falls from this line of logic, is that a conventional enemy would be able to achieve similar effects against USMC tanks and thereby bypassing the survivability advantages previously expected of a heavily protected AFV.

The proliferation of low cost and lightweight armour defeating ATGM's which can render heavily armoured formations combat ineffective at ranges greater than two kilometres, reduces the effectiveness, and thus the relevance, of heavy AFV within the CA.

CAVALRY BY DEFINITION

In 2021 the RCAC chose to adopt an Armoured Cavalry employment model, and assigned the RCAC school to define, refine and deliver the specific details of this strategic change in doctrine to the rest of the RCAC.[22] One of the challenges the RCAC faces during this doctrine transition is with defining precisely what it means to be "Cavalry". In 2015 Morin made a first attempt at defining what the cavalry concept for the RCAC should be in his paper "Cavalry: An Optimized Capability for ADO".[23] Morin defined a potential RCAC cavalry concept as:

> "… the mounted manoeuvre capability that can move, shoot and communicate, to include the spirit of an aggressive maneuver element capable of operating across vast distances for extended durations."[24]

The definition of Cavalry has continued to evolve over the past seven years, and has most recently been reconceived by Colonel Dove (Director Armour) in his February 2022 presentation to Canadian Army Doctrine Training Centre (CADTC) on the Armoured

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[22] Kessia, "The Role of Armoured Reconnaissance Within the Canadian Army," 17.

[23] Ryan Morin, "Cavalry: An Optimized Capability for Ado" (Joint Command and Staff College Course Paper, Toronto, ON, Canadian Forces College, 2015).

[24] Ibid., 9.

Cavalry concept. Colonel Dove defined the RCAC Armoured Cavalry concept as:

> "The role of Armoured Cavalry is to shape and define the battlefield by informing and protecting the commander's manoeuvre space and defeating the enemy through mounted manoeuvre."[25]

Both definitions of Armoured Cavalry effectively merge the traditional find capabilities of armoured-reconnaissance with the direct fire capabilities of armoured-heavy. It is important to note that neither of these definitions specifically requires a heavy armour component in order to be able to meet the definition of Armoured Cavalry.

Colonel Dove identifies in his brief to CADTC the challenge facing the RCAC and how the doctrinal change to Armoured Cavalry will enable the RCAC to accomplish the full spectrum of tasks required by the CA.[26] Figure 1 identifies the "Cavalry Gap", which represents the tasks assigned to the RCAC by the CA, and where the previous two stream model (Tank and Recce) fell short. As the RCAC shifts from the legacy two stream model and adopts the single stream Armoured Cavalry model, the RCAC will close the "Cavalry Gap" and "… thus able to accomplish the full range of the spectrum of armoured tasks with any close [combat vehicle]".[27]

Figure 1- The Cavalry Gap

Source: Colonel Dove, R.D. Armoured Cavalry: Cavalry By Heritage - Cavalry By Culture - Cavalry By Design

[25] Colonel Dove, R.D., "Armoured Cavalry: Cavalry By Heritage - Cavalry By Culture - Cavalry By Design."

[26] Ibid.

[27] Ibid.

While employing heavy AFVs which could ensure the survivability of the platform as well as its crew would be ideal, it is not specifically required by the RCAC in order to meet the definition of Armoured Cavalry. Heavy armour protection is also identified as a consideration within CA battle group doctrine when employing Armour, but it is not a role defining characteristic.[28] In all tasks within the "Spectrum of Armour" however, the effects of the mission can still be achieved with the absence of heavy armour and meet the definitions of Armoured Cavalry.

In broadly defining the RCAC as Armoured Cavalry and not as specifically as Armour-Heavy or Armoured-Reconnaissance, the heavy armour requirement has become less relevant as a criterion for RCAC AFV selection. As a consequence, the RCAC could explore acquiring lighter and highly mobile AFV capable of achieving superior levels of survivability through the novel application of advanced technologies.

THE FUTURE OF SURVIVABILITY

New advanced technologies that increase AFV survivability without adding more armour are appearing more frequently on the battlefield and further reduce the relevance of heavy armour.[29] Development programs funded by the US, United Kingdom (UK) and Russia are leveraging advancements in sensor technology, automation, drones, stealth and increased maneuverability to enable the levels of AFV protection that heavy armour previously provided.

Active Protection Systems (APS) such as the UK's Active Integrated Protection

[28] Canada. Department of National Defence, *B-GL-321-005/FP-001, Battle Group In Operations* (Kingston, ON: Canadian Army Doctrine and Training Centre, 2012), 3A1-2.

[29] Evans, "What Does the Future Hold for Tanks?"

System and Russia's Shtora-1 system[30] "…defeats threats before they strike a vehicle…".[31] APS systems use sensor systems integrated with the AFV to identify incoming threats and defeat them by either jamming the weapon (soft response) or by physically intercepting them prior to impact (hard response).[32] The aims of an APS system is to improve an AFVs survivability while minimizing its weight.[33] An alternative way to increase survivability is to avoid detection altogether. Innovative programs such as DARPA's Ground-X-Vehicle Technology (GXV-T) program are driving developments to reduce an AFVs detectable signatures "… including visible, infrared (IR), acoustic and electromagnetic (EM)".[34] When an AFV becomes harder to detect and target, its overall survivability increases without the need for additional armour.[35]

AFV survivability can also be increased through the integration of Unmanned Ground Vehicles (UGV) and Unmanned Aerial Vehicles (UAV) .[36] By integrating UAVs and UGVs as integral capabilities of an AFV, the crew would be capable of gathering intelligence, identifying targets and applying fires remotely and out of the enemies line of sight.[37] Russia's 38th Research and Testing Institute of Armoured Weapons and Equipment presented their "Future Russian tank" concept during the a conference in 2020 which illustrates their vision of UAVs and UGVs integrated into an AFV (see figure 2

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[30] Black, *Tank Warfare*, 521.

[31] Defence Science and Technology Laboratory, "Active Protection for Our Armed Forces" (GOV.UK, July 5, 2016), https://www.gov.uk/government/news/active-protection-for-our-armed-forces.

[32] Ibid.

[33] Ibid.

[34] DARPA, "Ground X-Vehicle Technologies."

[35] Evans, "What Does the Future Hold for Tanks?"

[36] Ibid.

[37] Brandon Morgan, "Light, Mobile, and Many: Rethinking the Future of Armor," Modern War Institute, January 3, 2019, https://mwi.usma.edu/light-mobile-many-rethinking-future-armor/.

below).[38] UGV autonomy and firepower capabilities will continue to advance and will eventually enable drone fire-team partners for the AFV crew in the same way that Australia is developing drone wingman for its air force.[39] Utilizing semi-autonomous UGVs as armoured fire-team partners to an AFV would allow an armoured formation to increase its firepower and footprint without increasing crew size, thus increasing the survivability of the overall formation.[40] Integrating UAVs and UGVs with AFVs will increase vehicle and crew survivability by enabling the engagement of targets beyond the AFVs line of sight, thereby reducing the crews exposure to direct fires.

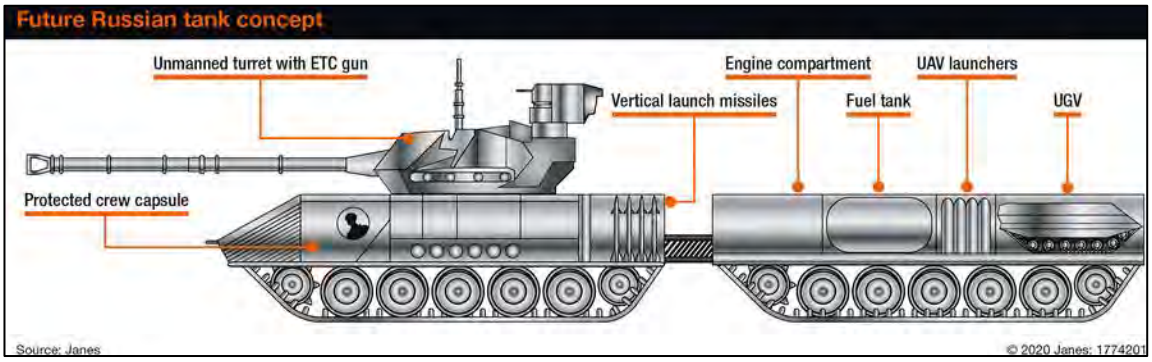

Figure 2 – Russian Future Tank Concept

Source: Janes Tank dreams. Mulling future Russian armour designs

Armoured forces are least vulnerable to enemy fires when they are able to outmaneuver the enemy using speed, agility and mobility. If an AFV can move faster than it can be targeted, and maneuver unrestricted across all terrain then its survivability increases. DARPAs GXV-T program understands this relationship, and are actively funding engineering research projects which will significantly enhance AFV mobility.

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[38] Jane's Group UK Limited, "Tank Dreams: Mulling Future Russian Armour Designs," Janes, accessed March 13, 2022, https://customer-janes-com.cfc.idm.oclc.org/InternationalDefenceReview/DisplayFile/FG_3762444?edition=2020.

[39] David Axe, "Boeing Drone Fighter Takes Flight In Australia—More Robotic Jets Could Follow," *Forbes*, March 2, 2021, https://www.forbes.com/sites/davidaxe/2021/03/02/australias-drone-fighter-takes-flight-more-robotic-jets-could-follow/.

[40] Evans, "What Does the Future Hold for Tanks?"

GXV-T's "Radical Mobility" project has a target to increase AFV speeds by 100% while simultaneously enabling access to 95% of terrain.[41] As AFV begin to achieve the "Radical Mobility" performance targets, it will be difficult for crews to keep up with the enhanced pace of battle and maintain effective situational awareness. Advances in crew augmentation technologies such as BAE systems 360 Multifunction Vehicle Protection (MVP) sensor platform, synthesizes sensor data to improve visibility, "… situational awareness, threat warning, and countermeasures to protect armoured vehicles and crews".[42] Developing automation programs which could access vehicle controls as well as AFV sensor data, similar to modern self-driving cars, could allow for even further survivability improvements. Automation could allow an AFV to "… autonomously avoid incoming threats without harming occupants…" faster than the crew could react independently.[43]

As outlined above, advancements in technologies which radically enhance AFV mobility, agility, stealth, speed and situational awareness are becoming more widely available and beginning to appear on the battlefield. These technologies increase AFV survivability without requiring additional armour, thus reducing the relevance of heavy armour as a requirement for CA AFV selection.

[41] DARPA, "Ground X-Vehicle Technologies."

[42] Jane's Group UK Limited, "Combat Vision: 'See-through' Armour Technology Advances towards ISR Roles," Janes, accessed May 29, 2022, https://customer-janes-com.cfc.idm.oclc.org/Janes/Display/BSP_11348-IDR.

[43] DARPA, "Ground X-Vehicle Technologies."

CONCLUSION

This paper has established that heavily armoured AFVs are less relevant to the CA due to the effectiveness of modern armour defeating weapons, the RCAC role change to Armoured Cavalry, and the developments of alternative technologies available to increase AFV survivability.

The effective use of ATGMs by the Ukrainian Army during the Russian invasion of 2022 to defeat Russian armour highlighted that heavy AFVs were unable to effectively protect crews as in decades previous.[44] The light weight fire-and-forget Javelin ATGMs was able to effectively destroy MBTs at ranges greater than two kilometres. At a cost of thirty-five times less than an MBT, the ATGM has rendered ineffective the protection advantages of heavy armour.

The RCAC move to adopt an Armoured Cavalry mindset has opened up new possibilities for AFV selection that do not necessarily mandate the use of heavy AFVs. By replacing the overly specific definitions of Armour-Heavy and Armour-Reconnaissance for the more platform agnostic definition of Armoured Cavalry, the RCAC now has the flexibility to choose AFV which are best suited to achieve their mission without the heavy-armour constraint.

Ensuring that AFVs are capable of providing sufficient survivability for the crews will always be a critical consideration for AFV selection. However, AFV survivability can be achieved through means other than additional armour. New and viable technologies can enhance the survivability of an AFV without the addition of armour by greatly enhancing vehicle speed, mobility, agility, stealth and crew situational awareness.

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[44] "How Tanks Can Survive against Cheap, Shoulder-Fired Missiles."

The modern battlefield is a highly lethal and complex environment. Utilizing AFV weight (light, medium and heavy) as a measure of performance is an outmoded approach to categorizing AFV capabilities. In order to ensure the CA and the RCAC have the capability to support the full spectrum of cross-domain warfare, it needs to consider how it defines its requirements for new AFV. It is very likely that future tanks may well end up not resembling the tanks of the past.[45] The future tank will be more lightly armoured, highly agile, hard to detect and have the ability to provide overwhelming fires over the horizon through the use of UAV and UGV.

In order to be positioned for success in the future, the CA should consider partnering with countries such as the US and UK who are investing in new AFV technologies through DARPAs GXV-T and BAEs 360 MVP programs. By partnering with these programs, the CA will be able to leverage emerging technologies and enable AFV procurement that increases crew and vehicle survivability while reducing overall AFV weight and cost.

[45] Peters, *Fighting for the Future*, 43.

BIBLIOGRAPHY

Amble, John. “How Will Technology Change Future Wars?” MWI Podcast: Accessed March 25, 2022. https://mwi.usma.edu/mwi-podcast-will-technology-change-future-wars/.

Axe, David. “Boeing Drone Fighter Takes Flight In Australia—More Robotic Jets Could Follow.” *Forbes*, March 2, 2021. https://www.forbes.com/sites/davidaxe/2021/03/02/australias-drone-fighter-takes-flight-more-robotic-jets-could-follow/.

“Battle Tank Cost - in 2022 - The Pricer,” March 24, 2022. https://www.thepricer.org/battle-tank-cost/.

Black, Jeremy. *Tank Warfare*. Bloomington, Indiana: Indiana University Press, 2020.

Canada. Department of National Defence. *B-GL-321-005/FP-001, Battle Group In Operations*. Kingston, ON: Canadian Army Doctrine and Training Centre, 2012.

CNN, Tim Lister, Tara John and Paul P. Murphy. “Here’s What We Know about How Russia’s Invasion of Ukraine Unfolded.” CNN. Accessed April 24, 2022. https://www.cnn.com/2022/02/24/europe/ukraine-russia-attack-timeline-intl/index.html.

Colonel Dove, R.D. “Armoured Cavalry: Cavalry By Heritage - Cavalry By Culture - Cavalry By Design.” In *RCAC Update to ATA / CADTC*. Gagetown, NB: Director Armour, 2022.

Cudmore, James. “Government Won’t Buy New $2B Armoured Vehicles for Army.” *CBC News*, December 19, 2013. https://www.cbc.ca/news/politics/government-won-t-buy-new-2b-armoured-vehicles-for-army-1.2470689.

DARPA. “Ground X-Vehicle Technologies.” Ground X-Vehicle Technologies (GXV-T). Accessed April 24, 2022. https://www.darpa.mil/program/ground-x-vehicle-technologies.

Defence Science and Technology Laboratory. “Active Protection for Our Armed Forces.” GOV.UK, July 5, 2016. https://www.gov.uk/government/news/active-protection-for-our-armed-forces.

Evans, Gareth. “What Does the Future Hold for Tanks?” *Army-Technology.Com*, January 2, 2017. https://www.army-technology.com/features/featurewhat-does-the-future-hold-for-tanks-5688047/.

The Economist. “How Tanks Can Survive against Cheap, Shoulder-Fired Missiles,” April 2, 2022. https://www.economist.com/science-and-technology/2022/04/02/how-tanks-can-survive-against-cheap-shoulder-fired-missiles.

Howard, Brad. “How This U.S.-Made, $176,000 Anti-Tank Weapon Could Change the War in Ukraine.” *CNBC*, April 29, 2022, sec. Defense. https://www.cnbc.com/2022/04/29/how-this-us-made-176000-anti-tank-weapon-could-change-the-war-in-ukraine.html.

Jane’s Group UK Limited. “Combat Vision: ‘See-through’ Armour Technology Advances towards ISR Roles.” Janes. Accessed May 29, 2022. https://customer-janes-com.cfc.idm.oclc.org/Janes/Display/BSP_11348-IDR.

Jane’s Group UK Limited. “FGM-148D Explorer.” Janes. Accessed May 27, 2022. https://customer-janes-com.cfc.idm.oclc.org/explorer/Equipment_92938?bc=04b29859-cda1-4e23-84bb-2d0e4fba6694&explorerState=61fd8a51-c06f-4092-900e-5411d69b8258.

Jane’s Group UK Limited. “Tank Dreams: Mulling Future Russian Armour Designs.” Janes. Accessed March 13, 2022. https://customer-janes-com.cfc.idm.oclc.org/InternationalDefenceReview/DisplayFile/FG_3762444?edition=2020.

Kessia, Vladimir. “The Role of Armoured Reconnaissance Within the Canadian Army.” *Canadian Military Journal* 22, no. 2 (Spring 2022): 10.

Lee, Michael. “Drones and Missiles: The Weapons Making a Difference in Ukraine.” *CTV News*, March 16, 2022, sec. World. https://www.ctvnews.ca/world/drones-and-missiles-the-weapons-making-a-difference-in-ukraine-1.5821581.

Lenihan, Donncha, William Ronan, Padraic E O’Donoghue, and Sean B Leen. “A Review of the Integrity of Metallic Vehicle Armour to Projectile Attack.” *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications* 233, no. 1 (January 1, 2019): 73–94. https://doi.org/10.1177/1464420718759704.

Morgan, Brandon. “Light, Mobile, and Many: Rethinking the Future of Armor.” Modern War Institute, January 3, 2019. https://mwi.usma.edu/light-mobile-many-rethinking-future-armor/.

Morin, Ryan. “Cavalry: An Optimized Capability for Ado.” Joint Command and Staff College Course Paper, Canadian Forces College, 2015.

Oryx. “Attack On Europe: Documenting Russian Equipment Losses During The 2022 Russian Invasion Of Ukraine.” *Oryx* (blog). Accessed April 24, 2022. https://www.oryxspioenkop.com/2022/02/attack-on-europe-documenting-

equipment.html.

Peters, Ralph. *Fighting for the Future: Will America Triumph?* 1st ed. Mechanicsburg, PA: Stackpole Books, 1999.

South, Todd. "Goodbye, Tanks: How the Marine Corps Will Change, and What It Will Lose, by Ditching Its Armor." Marine Corps Times, March 22, 2021. https://www.marinecorpstimes.com/news/your-marine-corps/2021/03/22/goodbye-tanks-how-the-marine-corps-will-change-and-what-it-will-lose-by-ditching-its-armor/.

"The Future of Armoured Warfare: 'Fly Light, Die Early'?" *Strategic Comments* 4, no. 8 (October 1998): 1–2.