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The Success of the Light Armoured Vehicle

Frank Maas

Abstract: Since the 1970s, budget constraints and debates over the tank's relevance have prompted the Canadian Forces (CF) to pursue lighter, cheaper, and more flexible vehicles. The Light Armoured Vehicle (LAV), built in London, Ontario, has been purchased in great numbers to satisfy these demands, and it has largely succeeded. The CF has purchased the LAV as a wheeled, multi-purpose vehicle to fulfill a variety of roles (infantry carrier, medical evacuation vehicle, etc.), that is cheaper and easier to maintain than tracked alternatives. The CF has continued to purchase LAVs because they have been successful in the field, and they support a domestic producer, General Dynamics Land Systems Canada (GDLS-C), that cooperates closely with the military.

The seeds for Canada's purchase of the Light Armoured Vehicle (LAV) lie as far back as 1964, when the Defence White Paper called for the creation of a force equipped with a flexible, light, and air-transportable vehicle to serve in UN missions. This resulted in a confused reaction that saw the Canadian Forces (CF) looking for a replacement tank for their troops in NATO while also trying to find a vehicle to serve with the UN, while the government was not willing to make the investment to procure either type.[1] Sean Maloney argues that the 1971 Defence White Paper, *Defence in the 70s*, released by the Trudeau government, was the turning point in the shift from tracked to wheeled vehicles in the CF.[2] The salient point was that the existing armoured vehicles were nearing the end of their operational life and the military had to have multi-purpose vehicles that could reduce the pressure on a limited defence budget.[3] This was combined with a growing sense in Canada that the nation should avoid high-intensity combat and focus on humanitarian operations, and the tank was not seen as a suitable vehicle for these operations. Moreover, the devastation of Israel's tank forces by modern anti-tank weapons in the Yom Kippur War of 1973 caused many to doubt the tank's primacy on the battlefield and whether it was worth the high cost for such a one-dimensional vehicle.[4] In this context, the Trudeau government purchased 114 Leopard I tanks in 1978 to replace the 500 Centurions procured by the Canadian Army in the 1950s,[5] but the Army still needed a vehicle for the reserves.

Faced with the urgent need for new vehicles and uncertainty about the nature of future operations, the Canadian military tried to choose a flexible vehicle.[6] With a shrinking defence budget, economy was an important reason why in 1974 the CF decided to pursue wheeled, light, and multi-purpose vehicles. The contract seemed destined to go to the American light armoured vehicle manufacturer Cadillac-Gage, but the owner of Swiss firm MOWAG, Walter Ruf, came to the Department of National Defence (DND) in Ottawa to present his company's new vehicle design, the "Piranha."[7] DND indicated that the vehicle must be built in Canada to have a chance of winning the bid, and the Swiss company solicited Diesel Division General Motors (DDGM), which had no military experience, but manufactured heavy equipment, to do assembly and steel fabrication work at their plant in London if the Piranha was selected. A multi-national competition was launched in 1976 for the Armoured Vehicle General Purpose (AVGP) program, a six-wheeled vehicle with four variants, and the Piranha was selected in March 1976 for the contract. Only three variants were produced: the Grizzly infantry carrier, the Cougar fire support vehicle, and the Husky maintenance vehicle. These vehicles were lightly armoured compared to tanks, and were intended to be training vehicles that might conduct peacekeeping or internal security operations. Production began in 1977, and DDGM assembled the vehicle and manufactured large steel components.

A total of 269 Grizzlies were built for the AVGP program and the vehicle was used mainly for reserves training in its prime role as an infantry carrier. Some units have been

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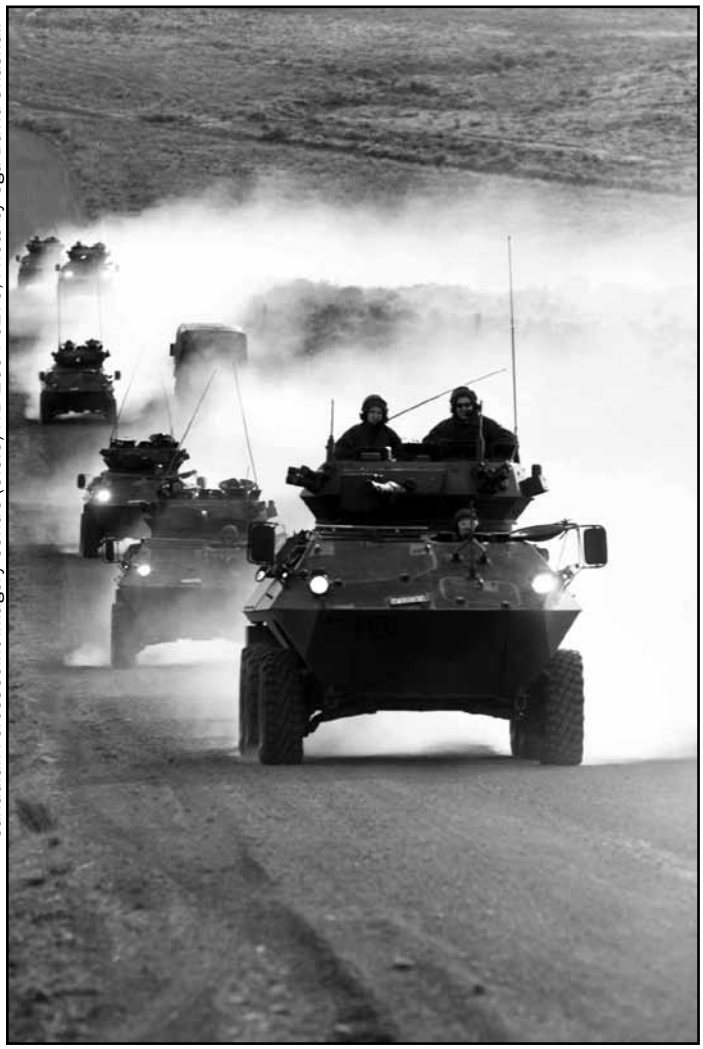


Canadian Forces Joint Imagery Centre (CFJIC) IVD 2004-0270, Photo by Sgt. David Snashall

Top: Three variants of the Armoured Vehicle General Purpose (AVGP), a six-wheeled vehicle, were introduced into Canadian service in 1976. (l. to r.) the Cougar fire support vehicle, the Grizzly infantry carrier, and the Husky maintenance vehicle.

Bottom: Cougar armoured vehicles from the Kelowna- and Vernon-based British Columbia Dragoons drive through the early morning light and dust. The Cougars are in the US Army training area of Yakama, Washington as part of Exercise Cougar Salvo held in March 2004.

life-extended to serve alongside the later Coyote and LAV-III as maintenance and recovery vehicles in Afghanistan.[8] The 195 Cougars delivered were equipped with a 76 mm main gun and a 7.62 mm machine gun to support infantry,[9] and these vehicles were given to reserve armoured regiments, but some were pressed into peacekeeping missions. There were 27 Huskies built and these maintenance and recovery vehicles still see active service in that role.[10] All the AVGP units were from ten to 13 tonnes, with armour protection designed to withstand fire up to a 7.62 mm machine gun.[11]

The AVGP vehicles were welcomed by the reserves.[12] The First Hussars regimental history described the Cougar as a "godsend" because it was a credible tank-trainer in contrast to the machine-gun armed jeeps that had been used; it improved the morale and retention of personnel.[13] Corporal Mark Fitz-Gerald of the First Hussars, who has deployed to Afghanistan, told the author that basic maintenance was easy; drivers could access the engines quickly and do much of the basic work. Chief Warrant Officer Jonathan Kisslinger of the same unit, who served in Bosnia in 1994 and more recently in Afghanistan, added that cleaning of the weapons systems was also easy.

There were, however, significant shortcomings. Fitz-Gerald described the AVGPs as being physically tight – for example, the turret was cramped in the Cougar, and maps, binoculars, and other equipment cluttered the space. The smell was often bad, as soldiers in heavy uniforms sweated and the fumes of weapons discharges filled the turret. Infantry in the Grizzly were crowded in the back, and jostled because the suspension of AVGP units was primitive compared to later vehicles. The vision ports were often blocked, and there were no cameras to give infantry points of reference. Fitz-Gerald stated that riding in the back of the AVGP was nauseating, especially when training runs lasted up to two hours. Deployment was difficult because infantry had to scramble out of small doors in the back, and were disoriented from the lack of reference points within the vehicle. The AVGP did not have any air conditioning, which made the vehicle very uncomfortable in hot weather.[14] Kisslinger said that there was limited exterior vision when the vehicle was "hatches down," as Army doctrine dictates, during combat. Staying coordinated and in line with the other vehicles was difficult. The Cougar's gun was not stabilized, and the vehicle had to be fully stopped or moving slowly for it to fire accurately. Having only two steerable wheels hampered the ability of the AVGP to turn in rutted roads or bad conditions, and also caused uneven weight dispersal.

Cougars were deployed to Somalia and Bosnia, and came under serious criticism for lack of armour protection, mobility, and firepower, hardly surprising in view of their design for training and low intensity operations.[15] The vehicles were sent

into active service with few spare parts because as training vehicles, they did not require the same level of maintenance as a front-line vehicle.[16] Kisslinger, nevertheless, emphasized that the Cougar showed considerable robustness in Bosnia. Its armour was generally proof against 7.62 mm bullets (depending on where they struck the vehicle and from what range), and the vehicle's high speed offered a degree of protection from anti-vehicle weapons. They also survived mine-blasts.[17]

After the success of the AVGP in Canada, the federal government suggested that DDGM look to export the Piranha to capitalize on its new plant in London.[18] DDGM made strong sales, to the United States Marine Corps, Saudi Arabian National Guard, Australia, and New Zealand, in addition to continued orders from the Canadian Forces. In 1999 Diesel Division General Motors of Canada was renamed GM Defence in recognition of its expanded military business responsibilities. Then, in 2003 after its acquisition by General Dynamics, it became General Dynamics Land Systems – Canada (DGLS-C).[19]

It was Canadian needs that drove the most significant development of the AVGP, the LAV-III. As always, financial considerations played a leading part. With the end of the Cold War, the Canadian government was particularly determined to realize a "peace dividend" in the face of soaring budget deficits. This was the reason for the precipitate withdrawal of Canadian Forces in Europe starting in 1992. Although the 1994 Defence White Paper noted dangerous volatilities in the international situation following the Cold War, its main theme was the need for economy and flexibility: "In short, the maintenance of multi-purpose forces represents a pragmatic, sensible approach to defence at a time of fiscal restraint." [20] The White Paper stated emphatically that Canada could not afford specialized equipment, and would only purchase what was absolutely necessary and easily maintainable.[21]

Two of the requirements highlighted in the White Paper were renewal of the ageing fleet of tracked armoured personnel carriers and the replacement of the old Cougars.[22] The most recent American tracked fighting vehicles, the M1 Abrams main battle tank and the M2 Bradley infantry fighting vehicle, were too expensive. MOWAG had developed the Piranha III from 1994-1995, which was a much larger version of the vehicle with a greater payload, better armour and an improved suspension and engine.[23] With Canada's previous purchase of the AVGP and other LAV

CFJIC IS2005-3031, Photo by Marc Lacourse

CFJIC ISD01-1018, Photo by Sgt Gerry Pilote

Above right: Grizzly and Husky armoured vehicles arrive in Dakar, Senegal aboard a Dutch commercial ship, 12 August 2005. Canada provided 105 armoured vehicles, training and maintenance assistance, and personal protective equipment in support of the efforts of the African Union Mission in Sudan (AMIS) to bring peace and stability to the Darfur region. The 100 "Grizzly" general purpose armoured vehicles and five "Husky" armoured recovery vehicles are being used by AU troops from Nigeria, Rwanda and Senegal.

Below right: Members of the 3rd Battalion, Royal 22e Régiment (3 R22eR) depart the Canadian platoon house in their Grizzly infantry section vehicle for their daily patrol, 12 November 2001. The 3 R22eR Battlegroup is with Task Force Bosnia-Herzegovina on Roto 9 of Operation PALLADIUM, Canada's contribution to the NATO Stabilization Force (SFOR).

variants, the political and financial contexts, and most important, Canada's production capability, the selection of the LAV-III was a predictable choice. DND decided on a directed purchase of the vehicle (no competition for the contract), which meant that the government could avoid the media scrutiny of a costly and time-consuming competition for a multi-billion dollar contract.[24]

An advantage of the well established relationship between DDGM and the Canadian Forces was that DDGM could pick and choose from the advances that MOWAG designers had developed in light of the CF's particular needs and preferences. According to William Pettipas, a former executive director of GM Diesel, the strength of MOWAG was research and development, while DDGM was better at integrated vehicle design, especially the cost-effective implementation of upgrades. The two companies could operate profitably without each other, but could cooperate closely when needed.[25]

The CF's purchase was the first sale of the LAV-III by either DDGM or MOWAG. Although wheeled armoured vehicles were not in vogue during the Cold War with larger combatants, they offered an attractive, cheaper alternative for smaller nations. The shift in military thinking after the Cold War to faster, quicker fleets adapting to multiple situations was beneficial for the company.[26] Tom de Faye, director of marketing and business development, stated that the decline of the Soviet threat reduced the need for heavy armoured vehicles, but increased the demand for cheaper, more versatile vehicles.[27] In the case of the LAV, the US Marine Corps, a service comparable in size and resources to the CF, had demonstrated the vehicle's capability in such varied roles as air defence, command and communications, and as mortar carriers. Hopes in Canada were that this flexibility, together with the increased protection and firepower of the LAV-IIIs, might make large savings possible by forestalling the need to replace the CF's Leopard tanks. The government was so cost-conscious and concerned about public perception of large investments in armoured vehicles that it bought the LAV-III in batches to hide the total cost of the program.[28]

DDGM started manufacturing the first batch of 240 LAV-IIIs for the Canadian Forces in 1998, and a wargame that same year, "Iron Renaissance," compared the LAV-III against the other APC of the Canadian Army, the M113. The study found that the LAV-III was much more effective and versatile than the M113 despite some limitations in mobility

Local Afghan children wave as Canadian soldiers from Task Force Kandahar pass by in a LAV III, January 2011.

on soft ground and vulnerability against anti-armour weapons. In the study, a Canadian battlegroup fought against an opposing motor rifle regiment with Soviet-style tactics in a defensive and offensive battle. The LAV-III's 25 mm cannon allowed it to engage threats at a greater range than the M113's heavy machine gun, and the vehicle's total enclosure of the crew reduced casualties because it protected them from artillery and indirect fire.[29] The LAV-III's speed, acceleration, and mobility, combined with the firepower of its 25 mm cannon and carrying capacity for specialized infantry weapons made it a more capable vehicle.[30] Although the LAV-III could not manoeuvre easily in the presence of enemy tanks, it incurred fewer losses and inflicted greater damage on the opponent than the M113.[31]

The experience of Corporal Fitz-Gerald and Master Warrant Officer Kisslinger with the LAV-III contrasted to the AVGP usefully highlights developments in design and performance. Kisslinger said that the LAV-III's hydropneumatic suspension was much superior to previous vehicles, and allowed operation at higher speed with better crew comfort. The engine was more powerful, and technological advancements, such as thermal imagery, self-diagnostic maintenance systems, and improved fire-control made the LAV-III much more effective. The infantry compartment was larger, and the sergeant's camera that displayed the area in front of the vehicle reduced disorientation among the embarked infantry, and allowed them to deploy more effectively. Fitz-Gerald added that the ramp on the vehicle was a significant improvement, allowing infantry to deploy much faster. Finally, and very importantly, the LAV-III has air conditioning, which is a significant advantage in hot environments.

The LAV-III has served in low intensity operations of the type that the LAV type was originally designed, in Ethiopia and Eritrea, the Balkans, and Haiti, but has also seen a great deal of combat with the International Security Assistance Force (ISAF) in Afghanistan.[32] The Canadian Army realized quickly that it needed heavy vehicles to combat the Taliban insurgency, and sent additional LAV-IIIs and Bison armoured vehicles after first deploying.[33] Yet the Taliban has used increasingly powerful roadside bombs and weapons, and no vehicle is immune.[34] The goal of the insurgents is not necessarily to destroy the vehicle, but to kill the personnel inside it; the high pressure of large anti-tank mines or other bombs can savage the troops inside any vehicle. Since the middle of 2006, LAV-IIIs have come under more frequent attack by the Taliban. A Lesson Synopsis Report in response to an Improvised Explosive Device (IED) from May 2009 stated that "no amount of armour could prevent a catastrophic vehicle kill," and that the best method of defeating IEDs is in proper reconnaissance and route choice.[35] As IED attacks intensified, military commanders reaffirmed the utility of the LAV-III and that no vehicle is immune.[36] By mid-2008, the Army was considering replacing or upgrading the LAV-III, which has seen tough service in Afghanistan, and was not designed to meet threats like IEDs. Even so, the vehicle's capabilities and versatility earned the confidence of its crews.[37] Kisslinger stated that the LAV-III is robust, well-armed and popular

CFJIC APD02 5000-134, Photo by Cpl Lou Penny

CFJIC ISO2010-4023-04

Above right: A Coyote armoured reconnaissance vehicle watches the perimeter of the Kandahar airfield. The mast-mounted radar of the Coyote's surveillance system scans for suspicious activity and can "see" up to 24 kilometres away. Photo taken in March 2002.

Below right: A Coyote provides overwatch at the Vancouver International Airport during the 2010 Summer Olympic Games.

CFJIC AR2011-0025-121, Photo by Tina Gillies

CFJIC APD02 5257, Photo by Lou Penney

CFJIC IS2003-2493a, Photo by Frank Hudec

CFJIC VK2003-0121-05d, Photo by Roxanne Clowe

Top left: Under a flag flying at half-mast to mark the death of the Queen Mother, a Bison infantry section vehicle brings (from left) Vice Admiral Greg Maddison, the deputy chief of the defence staff, Lieutenant-Colonel Pat Stogran, the commanding officer of the 3rd Battalion, Princess Patricia's Canadian Light Infantry Battle Group, and Lieutenant-General Mike Jeffrey, the chief of the land staff, to the Canadian camp at Kandahar International Airport to deliver a briefing to the soldiers of the 3 PPCLI Battle Group, 30 March 2002.

Middle left: A Canadian Forces Bison maintenance and recovery vehicle sits in a compound at night at the Canadian International Security Assistance Force (ISAF) camp in Kabul, Afghanistan, 13 July 2003.

Bottom left: An armoured Bison ambulance and its crew are serving a six-month mission maintaining a safe and secure environment in Bosnia on Operation Palladium, a NATO peace-support mission and Canada's contribution to peace in the Balkans. This photo was taken in Velika Kladusa, Bosnia-Herzegovina on 28 May 2003.

with personnel; Fitz-Gerald agreed that the LAV-III platform and its technologies performed well in Afghanistan.[38]

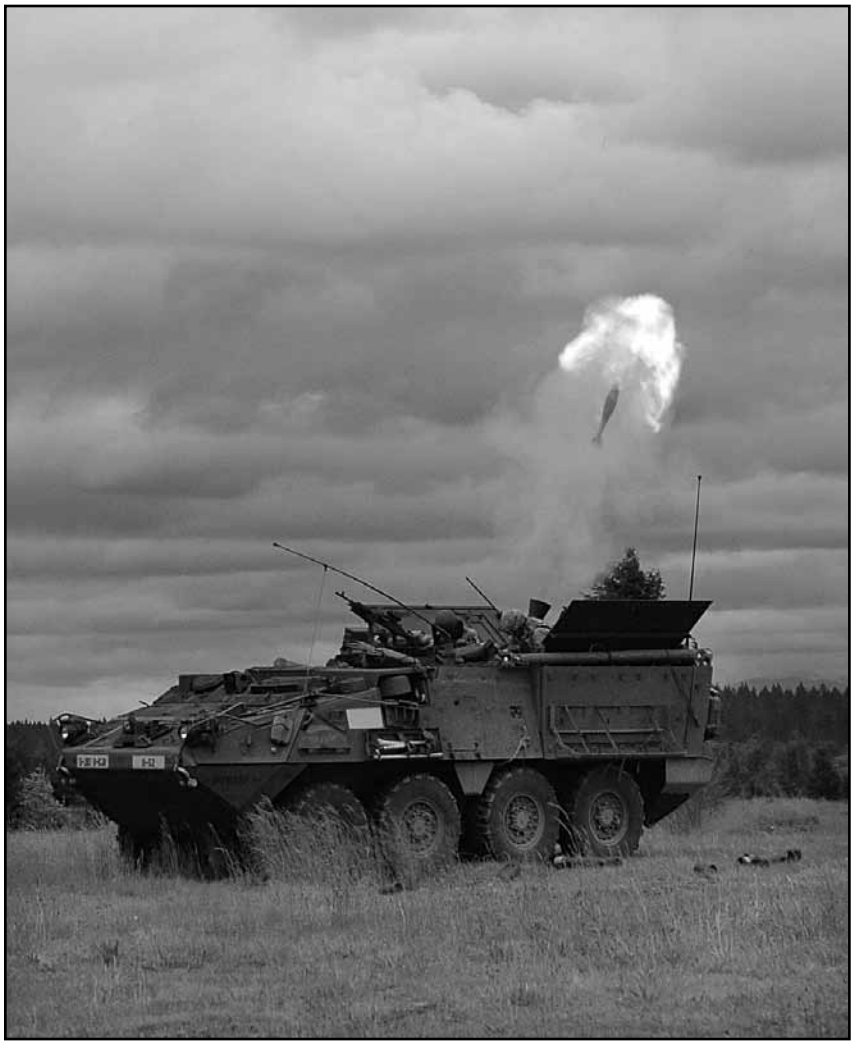
GDLS-C has positioned itself as the sole supplier of armoured vehicles for the Canadian Forces, and has adapted itself to Canada's particular context: budgetary constraints even as the country undertakes international military missions in diverse challenging environments. During the AVGP bid of the 1970s, Army officers wanted to re-equip the armoured forces with a new main battle tank, but could not overcome the government's unwillingness on the score of cost and public perceptions of tanks as offensive weapons inappropriate to Canada's foremost international role as a peacekeeper. In the end the Army had to settle for a limited number of Leopard tanks, mainly to sustain the armoured regiment in Europe, and a larger number of wheeled tank trainers that could

perform in low-intensity operations, such as internal security at home, and peace-monitoring missions for the UN. AVGPs were low-maintenance compared to tracked vehicles, particularly so because a common platform filled multiple roles; troops did not have to service a variety of vehicles.

The AVGPs have been in service for much longer than expected, and have been continuously rebuilt and re-roled. Colonel Fred Lewis boasted in 2004 that the Canadian Army was a NATO leader in converting to faster, wheeled fleets that could capitalize on enhanced intelligence gathering capabilities and use their speed to eliminate targets quickly.[39] This continuing commitment to wheeled vehicles as a primary combat type was not intended. In circumstances that echoed those that surrounded the original AVGP acquisition in the 1970s, the CF bought the LAV-III at a time of severe financial stress, and acute need for new equipment in the face of uncertainty about requirements in a rapidly changing international environment. DDGM's LAV-III was selected in 1995 because the company had a strong record as a contractor for the Canadian Forces. They had a new, upgraded and capable vehicle whose predecessor had proven itself. There was commonality with many other vehicles in Canadian service, and the CF had combat and maintenance personnel who were already familiar with the LAV. The LAV-III could fulfill a variety of tactical roles, from infantry to missile carriers, and it was also upgradeable, which built on an important element of the Canadian Army's relationship with the LAV family: "platform improvement."[40]

The Piranha family of Light Armoured Vehicles manufactured in London, Ontario has been a successful military technology. Although the market is demanding and competitive, GDLS-C has made itself

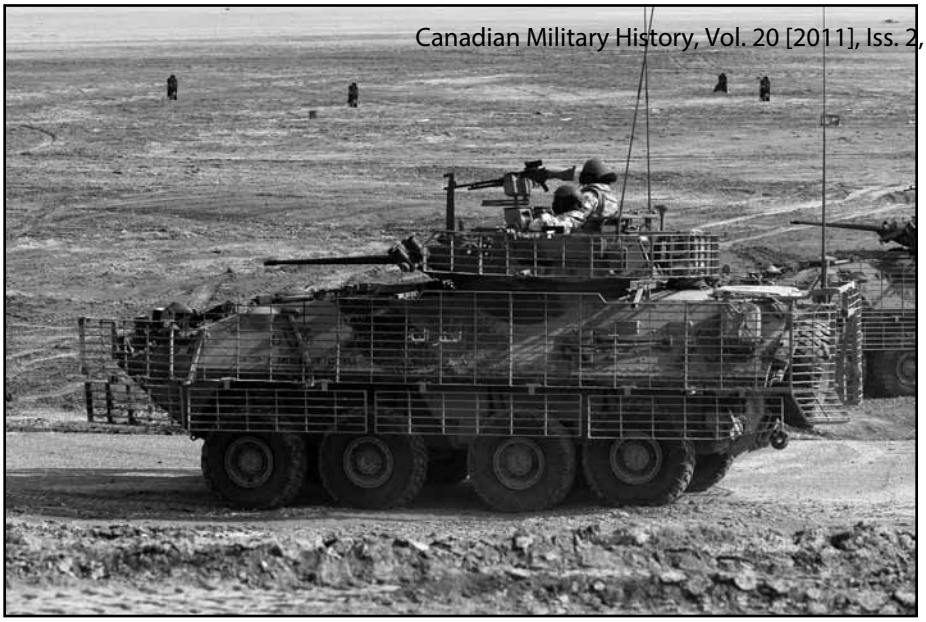
US Army photo 2007-12-21-093616



US Army photo 2008-06-04-071324

Top: A US Army Stryker NBCRV (nuclear, biological and chemical reconnaissance vehicle) is an NBC testing lab on wheels. Here it is on display at the Pentagon in Washington, DC, December 2007.

Above: Soldiers from B Troop, 8th Squadron, 1st Cavalry Regiment, fire a 120 mm mortar from their Stryker during crew certification at Fort Lewis, Washington, May 2008.



Australian Department of Defence (ADOD) photo 20071230adf8243116-311

ADOD photo 20080517ran8100279-175-drn

United States Marine Corps Photograph

Light Armoured Vehicles in foreign service.

Left: An Australian LAV testing its equipment on a practice range near Tallil Air Base in Southern Iraq,

Below left: A Royal New Zealand LAV participates in "JOINT KIWI 08," an exercise held on the South Island of New Zealand and aimed at improving interoperability with the Australian military.

Bottom left: United States Marine Corps scouts with the Light Armored Vehicle platoon, 15th Marine Expeditionary Unit take cover behind an LAV-25 prior to beginning a trench assault in the Jordanian desert during "Operation Infinite Moonlight," August 2008.

into the pre-eminent manufacturer of light armoured vehicles, formerly a European domain.[41] From an original design nearly 40 years old, GDLS-C and MOWAG have progressively developed the armoured vehicle into three distinct variants with many capabilities. The original Piranhas were light vehicles, approximately ten tonnes, and recent updates of the LAV have taken it to nearly 30 tonnes, to accommodate increases in firepower, protection, engine power, and technological innovation.[42] The company has been successful because of the vehicle's combat performance; the LAV has acquitted itself well and it is generally liked by its crews. There have been problems, but no vehicle is perfect.

However, selling the vehicle and ensuring customers stay satisfied requires more than just having a good product. The foundation for GDLS-C's success is its domestic market: Canada. The CF's purchase of the AVGP was the London company's foothold on the light armoured vehicle market, and subsequent purchases have cemented GDLS-C's role in the Canadian defence establishment. DND has found ways to support GDLS-C because it is the only manufacturer of armoured vehicles in Canada and is a significant industry. Under

the Canada-US Defence Production Sharing Agreement, moreover, GDLS-C can bid on US contracts and be treated like a US company. The Canadian government has also actively assisted GDLS-C in selling its product.[43] William Pettipas stated that "soldiers are our best salespeople,"[44] and the CF's purchase and stamp of approval on the LAV has paved the way for large American contracts and other foreign sales that have helped the company grow.

The second aspect of GDLS-C's success is the hiring of former or reserve military personnel, a common practice among defence contractors.[45] William Pettipas was a military officer for 28 years before joining the company,[46] and his first-hand knowledge of what soldiers need and expect has helped the company immensely. Designers, such as Mike Stapleton, are reservists who have trained and worked with LAVs, and are aware of the sometimes unusual requirements of military personnel. This helps them to provide solutions that address those requirements, and the connection with military culture and common "language" strengthens the understanding between the CF and GDLS-C. An article in the *Maple Leaf* described the experience of GDLS-C employee Mark Campbell, who is in the Army Reserves. He stated that the support he received from the company was "absolutely amazing," and that GDLS-C was very good in accommodating its reservists in pay and leaves. He noted there are 16 employees in GDLS-C who are currently active in the reserves, and that this enhances "a strong understanding of military equipment requirements from the perspective of the end user."[47] William Pettipas agrees that the hiring of former or reserve military personnel is beneficial for the design of the vehicle as well as corporate relationships. Former military personnel at the higher levels of the company create understanding between the purchasers and the company, and enhance the credibility of the producer.[48]

The LAV and GDLS-C are attractive because they reduce the maintenance burden on militaries. A high maintenance load can cripple combat efficiency and budgets, and the high cost of acquiring vehicles means that combat platforms are kept in service for a long time: sometimes up to 30 years. The LAV meets requirements for a reliable, maintainable vehicle that can perform a variety of roles. GDLS-C's branch plant in Edmonton and another workshop in London, and the subcontractor Militex Coatings Inc have done much of the refurbishment and reworking for these vehicles. The shared experience of the Canadian, American, Australian, New Zealand, and Saudi Arabian militaries reduces the maintenance burden in NATO or ABCA, and the LAV User Nations Group was created to build on this shared knowledge.[49]

Finally, the LAV is upgradeable, a key requirement in an era of ceaseless change. For example, the LAV-III was designed in the mid-1990s with no anticipation of the threat of IEDs in Iraq and Afghanistan. Defence contractors and militaries have been forced to react to this threat, and lately, GDLS-C has aggressively researched survivability and armour upgrades to contend against roadside bombs.[50] GDLS-C has produced the LAV-H, which is a technology demonstrator to show the capabilities that can be achieved with a refurbished LAV-III. The LAV-H was built with the experience and recommendation of former operators from Afghanistan.[51] Improving the vehicle with operator experience is not a standardized process, rather an informal series of discussions with military personnel.[52] Because it was designed as a troop carrier, there is room in the large compartment in non-infantry variants for electronics packages, or other equipment and weapons such as mortars.

Since the LAV was first purchased in the 1970s defence budgets have continued to be tightly constrained and the military has not enjoyed the flexibility in procurement it had during the Second World War and the early Cold War. Rather, the CF must economize while being called upon to perform more varied roles, even as more lethal threats

US Army photo 45538-2009-07-22-100705

US Army soldiers patrol through Sab al Bour, a town north of Baghdad, with a column of Strykers providing support, July 2009.

dictate the employment of new, costly technology. The LAV, despite the age of its original design, has been continually improved to meet new demands, and its producer has continually adapted itself to respond effectively to its market and customers.

Notes

1. Sean Maloney, "A Proportion of Their Cavalry Might Be Converted: Light Armoured Force Development in Canada's Army, 1952-1976," *The Army Doctrine and Training Bulletin* 2, no.4 (1999), p.91.
2. Ibid., pp.97-99.
3. Canada, Department of National Defence, *Defence in the 70s* (Ottawa, 1971), <http://www.forces.gc.ca/admpol/newsite/downloads/Defence%20in%20the%2070s.pdf> (accessed 23 June 2009), pp.16, 35.
4. Adrian R. Lewis, *The American Culture of War* (New York: Routledge, 2007), p.301.
5. Lee Hammond, "Tank: The Canadian Army's Four-Letter Word," *The Army Doctrine and Training Bulletin* 4, no.4 (2001), p.79.
6. Maloney, "A Proportion of Their Cavalry Might Be Converted," p.99.
7. William Pettipas (former Executive Director, GMD), in discussion with the author, July 2009).
8. Canada, Canadian Army, *Grizzly AVGP (Armoured Vehicle General Purpose)* (Ottawa, 2009), <http://www.army.forces.gc.ca/land-terre/equipment-equipement/item-eng.asp?product=71> (accessed 17 June 2009).
9. Canada, Canadian Army, *Cougar* (Ottawa, 2009), http://www.army.forces.gc.ca/land-terre/equipment-equipement/item-eng.asp?product=57 (accessed 17 June 2009).
10. Canada, Canadian Army, *Husky* (Ottawa, 2009), <http://www.army.forces.gc.ca/land-terre/equipment-equipement/item-eng.asp?product=62 (accessed 17 June 2009)>.
11. Sean Maloney, "A Proportion of Their Cavalry Might Be Converted," 97-101.
12. John Marteinson and Michael McNorgan, *The Royal Canadian Armoured Corps* (Altona, Manitoba: Friesens, 2000), p.391.
13. Michael McNorgan, *The Gallant Hussars* (Aylmer: The Aylmer Express, 2004), p.236.
14. Corporal Mark Fitz-Gerald, in discussion with the author, July 2009.
15. Lee Hammond, "Tank: The Canadian Army's Four-Letter Word," *The Army Doctrine and Training Bulletin* 4, no.4 (2001), p.79.
16. Brian Nolan and Scott Taylor, *Tested Mettle* (Ottawa: Esprit de Corps Books, 1998), p.113.
17. Master Warrant Officer Jonathan Kisslinger, in discussion with the author, July 2009.
18. Pettipas, in discussion with the author, July 2009.
19. Margaret Brady, "Amour with Armour," *National Post*, 20 November 1999, <http://www.proquest.com>.
20. Canada, Department of National Defence, *1994 White Paper on Defence* (Ottawa, Canada [1994]), <http://www.forces.gc.ca/admpol/newsite/downloads/1994%20White%20Paper%20on%20Defence.pdf> (accessed 23 June 2009), p.16.
21. Ibid, p.31.
22. Ibid, p.35.
23. Christopher Foss, ed., *Jane's Armour and Artillery 2007-2008* (Surrey, United Kingdom: Jane's Information Group, 2008), pp.480-81.
24. J. Stone, "An Examination of the Armoured Personnel Carrier Replacement Project," *Canadian Military Journal* 1, no.2 (2001), p.63.
25. In discussion with the author, July 2009.
26. Margaret Brady, "Amour with Armour,"
27. Doug Alexander, "General Dynamics Land Systems-Canada," *Canadian Defence Review – Company Profile*, (2004), p.3.
28. J. Stone, "An Examination of the Armoured Personnel Carrier Replacement Project," *Canadian Military Journal* 1, no.2 (2001), p.63. Allan Thompson, "GM in London gets big military order," Toronto Star, 17 August 1995, <http://www.lexisnexis.com>.
29. Department of National Defence, Operational Research Division, *Iron Renaissance: Evaluation of the LAV-III Combat Team in Conventional Operations*, by P. Bender, M. Ormrod, and D. Davision. (Ottawa, 2009), <http://cradpdf.drdc.gc.ca/PDFS/zbb72/p510769.pdf> (accessed 22 June 2009), ii-iii.
30. Department of National Defence, *Iron Renaissance*, p.v.
31. Ibid., pp.23-24.
32. Foss, *Jane's Armour and Artillery 2007-2008*, pp.480-81.
33. "DND Announces more Armoured Vehicles for Afghanistan," *Army News*, 17 October 2003, <http://www.lexisnexis.com>.
34. Marco Comisso, "The APV Revisited," *Army News*, 1 August 2007, <http://www.army.forces.gc.ca>.
35. Army Lessons Learned Centre, *Consolidated Lesson Synopsis Report (09-008) on Improvised Explosive Device (IED) Incidents in March 2009*, (Kingston, 2009).
36. Richard Brennan, "'It does the job,'" *Toronto Star*, 10 April 2007, <http://www.lexisnexis.com>.
37. Kisslinger and Fitz-Gerald, in discussion with the author, July 2009.
38. Kisslinger, in discussion with the author, July 2009.
39. Paul Mooney, "Sappers prepare for transformation," *Army News*, 8 June 2004, <http://www.army.forces.gc.ca>.
40. Canada, Directorate of Land Strategic Concepts, *Future Army Capabilities: Command, Act, Shield, Sustain, Sense* (Kingston, 2001), http://www.army.forces.gc.ca/DLCD-DCSFT/pubs/archive/Future_2001_e.pdf (accessed 25 June 2009), p.44.
41. Ezio Bonsignore, "Back to the Future," *Military Technology* (November 2000), pp.8-14.
42. Foss, *Jane's Armour and Artillery 2007-2008*, p.480.
43. Pettipas, in discussion with the author, July 2009.
44. Canada, *Standing Committee on National Defence and Veterans Affairs – November 30, 1999* (Ottawa, 2009), <http://www2.parl.gc.ca/HousePublications/Publication.aspx?DocId=1039901&Language=E&Mode=2&Parl=36&Ses=2> (accessed 13 July 2009).
45. Rachel Weber, *Swords Into Dow Shares: Governing the Decline of the Military Industrial Complex* (Boulder: Westview Press, 2001), p.51.
46. *Standing Committee on National Defence and Veterans Affairs – November 30, 1999*. <http://www2.parl.gc.ca/HousePublications/Publication.aspx?DocId=1039901&Language=E&Mode=2&Parl=36&Ses=2> (accessed 13 July 2009).
47. Ian Livermore, "Canada Shows Its Support to Reserve Force Troops," *Maple Leaf*, 13 September 2006, <http://www.forces.gc.ca>.
48. Pettipas, in discussion with the author, July 2009.
49. NATO - North Atlantic Treaty Organization; ABCA – American, British, Canadian, Australian and New Zealand Armies' Program; The LAV User Nations Group consists of representatives from United States Marine Corps, United States Army, Canada, Australia and New Zealand. Ffion Llewd-Jones, "Canada's #1 Defence Company," *Canadian Defence Review* 14, no.2 (2008), p.4.
50. Ibid, p.3.
51. Kenneth Yamashita (manager of corporate affairs, GDLS-C), in discussion with the author, July 2009.
52. Todd Berry, "Bison Mobile Repair Team vehicle delivered to CF," *Army News*, 26 May 2009, <http://www.army.forces.gc.ca>.

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