

**Spring 2018
Industry Study**

**Industry Report
Land Combat Systems**

13

REVIEWED BY DOD

DEFENSE OFFICE OF PREPUBLICATION AND OFFICE OF SECURITY REVIEW

NO CLASSIFIED INFORMATION FOUND

Mar 20, 2019



**The Dwight D. Eisenhower School for National Security and Resource Strategy
National Defense University
Fort McNair, Washington, D.C. 20319-5062**

19-S-0830

LAND COMBAT SYSTEMS (LCS) 2018

ABSTRACT: The Land Combat Systems (LCS) industry is critical to the national security of the United States because it provides the very means by which American ground forces (Army and Marines primarily) fight and win our nation's wars. The US established itself as a world leader in this industry as it implemented the second offset but has made only incremental upgrades to that fleet over the past decades. To maintain parity and reclaim a degree of technological advantage among ground forces around the world, the United States must husband its resources carefully and develop thoughtful strategies to sustain the LCS industrial base, develop new systems or upgrades that provide the right mix of capabilities to accomplish assigned missions, and field them to the force.

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Chapter 1. A Global View of the Combat Vehicle Industry

“Trends indicate combat vehicles are growing even more important, as urbanization complicates tactical problems, and sophisticated technologies boost the lethality of weapons. Army formations need combinations of mobility, protection, and lethality to seize, retain and exploit the initiative against all potential adversaries.”¹

General Daniel B. Allyn
Vice Chief of Staff, United States Army

Security Drivers for the Combat Vehicle Market

There are multiple security drivers that shape the global combat vehicle market. Most prevalent and enduring amongst these drivers are current and anticipated future threats, obsolescence of current capabilities, and the size of defense budgets. These three factors shape the market by creating demands for capabilities necessary to deter or defeat adversaries within each nation’s means.

This chapter provides an overview of the global combat vehicle market by describing security drivers, market and vehicle trends, global firms, key products, and recent technological innovations. It also provides general analysis and conclusions about the worldwide combat vehicle market. Subsequent chapters provide greater detail and analysis of regional and national combat vehicle markets and stand on their own to allow the reader interest driven investigation.

Global Tensions. The most important driver of demand for combat vehicles in the global market is the nature and extent of the threats nations face. Areas of the world experiencing a considerable amount of interstate tensions and conflicts, such as the Middle East and North Africa, generally have a relatively high demand for combat vehicles. Regions of the world experiencing low levels of interstate tension and conflict, such as South America, spend very little on combat vehicles. Indeed, significant spending on acquiring, upgrading and sustaining combat vehicles was observed during the last two decades in the following “hot spots” around the globe²:

- Afghanistan (civil war)
- Algeria – Morocco (territorial conflict)
- Armenia – Azerbaijan (territorial and ethnic conflict)
- China – Japan (tensions in the East China Sea, Senkaku Islands dispute)
- China – Philippines & Vietnam (territorial disputes in the South China Sea)
- India – China (border dispute)
- India – Pakistan (territorial and ethnic conflict)
- Iraq (civil war)
- Iran – Gulf Cooperation Council States (regional non-state actor proxy conflict)
- Israel (territorial and ethnic conflict)
- Korea (border tensions)
- Libya (civil war)

- Russia – Baltic Nations (Estonia, Latvia, Lithuania)
- Russia - Georgia (territorial and ethnic conflict)
- Russia - Ukraine (Crimea, territorial and ethnic conflict)
- Syria (civil war)
- Turkey (Kurds, Syria)
- Venezuela (civil unrest)
- Yemen (civil war)

Defense Spending. In addition to threats to national security, a nation's fiscal capacity to fund defense programs is an important determinant of demand for combat vehicles. A nation facing relatively low threats but possessing a high fiscal capacity to fund national defense may spend more on combat vehicles than a nation facing high threats but possessing few resources.

Countries facing similar threats might buy very different combat vehicles simply due to differences in fiscal resources. A wealthy country might buy expensive tanks and highly capable tracked infantry fighting vehicles (IFV) to address a particular threat while a less wealthy country might address a similar threat by supplying its land forces with a fleet of wheeled 8x8 combat vehicles equipped with small and medium caliber weapons and anti-tank guided missiles.

Around the globe, the demand for combat vehicles often tracks changes in economic conditions. When oil prices decline, nations in the Middle East tend to reduce and slow down spending on combat vehicles due to reduced fiscal resources. Similarly, spending on combat vehicles by European nations declined significantly during and after the great recession of 2008-2009.

Fleet Obsolescence. Another important driver of combat vehicle spending is the rate at which combat vehicles become obsolete in the face of new threats or technology. More lethal anti-tank guided missiles (ATGMs), rocket-propelled grenades (RPGs), improvised explosive devices (IEDs), and cyber warfare have motivated countries to either modernize their combat vehicles or procure new ones. Similarly, new technologies make it possible to design models with new capabilities. For example, some nations are beginning to experiment with having manned vehicles operate in tandem with an unmanned partner. As this technology matures, it will likely result in radically different vehicle designs. Even in the absence of revolutionary changes in technology, nations eventually buy new models for economic reasons. Older vehicles generally tend to cost more to man and operate than new and only provide a fraction of the capabilities of current models. As more nations abandon older models in favor of new, it becomes increasingly difficult and more expensive to acquire repair parts needed to sustain aging fleets. This additional sustainment cost gives impetus for nations to replace older combat vehicles with newer models.

Global Combat Vehicle Market Summary

Without argument, the global market for combat vehicles is on the rise. In both quality and quantity, the resurgence of state and multi-national threats has stoked demand for the development and delivery of modern weapon systems around the world. Furthermore, the increasingly rapid state of commercial technological innovation promises to answer that demand with increasingly capable defense applications delivered by both large Original Equipment Manufacturers (OEM) and non-traditional players operating in a highly competitive global market place. In 2016, the total military vehicle market is estimated to have earned revenues of

approximately \$35B for research, development and the procurement of new and upgraded weapon systems, delivering over 30,000 new and upgraded vehicles.³ By 2025, the market is forecasted to expand to over \$45B in total annual revenue (6.6% Compound Annual Growth Rate) with the average price increasing at a rate of over 5% per year reflecting the high degree of technological advances resident in each system. According to Jane's, over \$443B will be spent on research, development, production, and modernization of military vehicles between 2016 and 2025.⁴ On average, innovation is incremental and accelerating, resulting in land combat systems that are increasingly more expensive to develop and fielded in decreasing time increments.⁵ Furthermore, the total number of systems is predicted to remain fairly steady as national preference shifts to quality over force structure growth as a means of countering rising threats.

Table 1: CV Spending by Category⁶

Military Ground Vehicle Spending	(2016-2025)
Total	\$443.3
New Build	\$343.7
Upgrades	\$52.8
Other (R&D, Unidentified)	\$46.8

Combat Vehicle Trends. In terms of product type, there is growing demand for nearly all classes of combat vehicles. Globally, aging light and medium weight requirements have created intense interest in wheeled vehicle solutions, continuing the trend from the 1990s of replacing tracked with wheeled combat vehicles due to their cost advantages and technological advances that have eroded the mobility advantage of tracked vehicles in the 30 ton and lower weight class.⁷ In 2000, most CVW weighed less than 20 tons. By 2010, newer CVW models in Europe and North America weighed nearly 30 tons (AMP, LAV 6, Piranha V, Stryker, and VBCI), while the German Boxer weighed in as the heaviest 8x8 CVW with a combat weight approaching 40 tons. In order to offset the loss of mobility caused by increased weight, CVW designers have moved to larger tires with less rolling resistance and bigger footprints to maintain a sufficiently low ground pressure. They have also adopted more powerful engines and sophisticated independent suspension systems to include height-adjustable semi-active hydropneumatic suspensions.⁸ Some nations such as Lithuania and Australia have opted to put unmanned turrets with medium caliber weapons on newer, heavier 8x8 wheeled combat vehicles and use them as a reconnaissance or Infantry Fighting Vehicle (IFV), a role typically performed by medium weight tracked vehicles, such as BAE Hagglands CV90.

Meanwhile, global defense powers continue to express significant interest in next generation main battle tank (MBT) and tracked IFV solutions that resist obsolescence in the face of modern threat projections. Six nations specifically have led the way to develop and produce new MBT models, including India's Arjun in 2004, Japan's Type 10 in 2012, Korea's K2 in 2014, China's VT-4/MBT-3000 in 2015, and Russia's T-14 Armada and Turkey's Altay, both of which are expected to go into production in by the end of the decade.⁹ Both Germany and the United States have invested heavily to upgrade existing fleets of the Leopard 2 and M1 MBT. As shown in **Figure 1** and **Figure 2** below below, MBTs will account for almost a quarter of CV market revenues over the 2016-2025 forecast period (23%). Perhaps less obvious, this investment represents only 7.1% of the total number of systems programmed while over 51% of

total value and volume will be applied to the procurement of Armored Personnel Carriers (APC) and IFVs.¹⁰

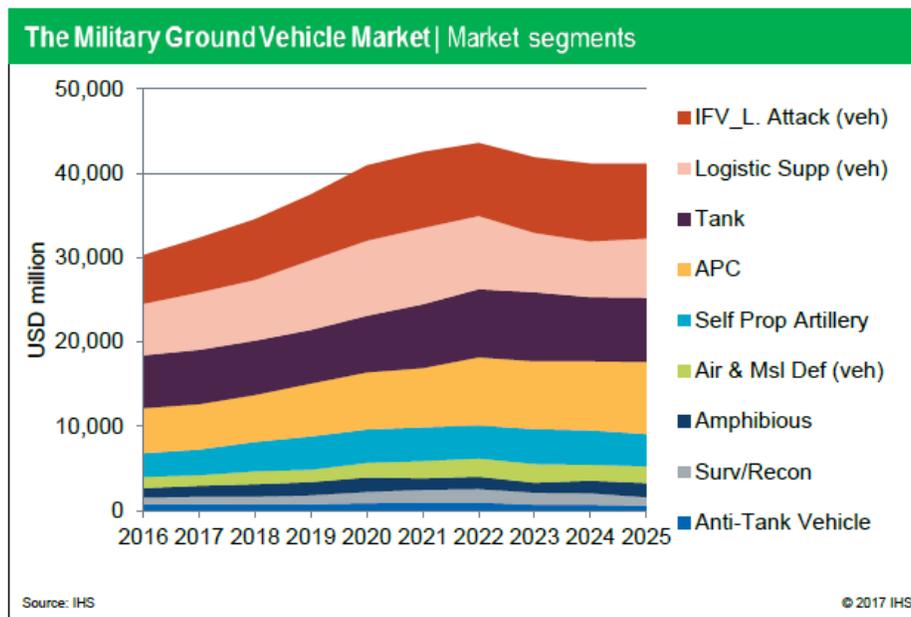


Figure 1: CV Revenue by Type¹¹

COMBAT VEHICLE SPENDING	(2016-2025)	
Main Battle Tanks	\$71.4	23%
Infantry Fighting Vehicles and Amphibious Assault Vehicles	\$95.1	31%
Armored Carriers + Anti-Tank Vehicles	\$77.1	25%
Reconnaissance Vehicles	\$11.8	4%
Self-Propelled Artillery	\$37.3	12%
Air Defense Vehicles	\$17.5	6%
Total Combat Vehicles	\$310.2	100%
Trucks	\$75.6	

Figure 2: CV Revenue by Type¹²

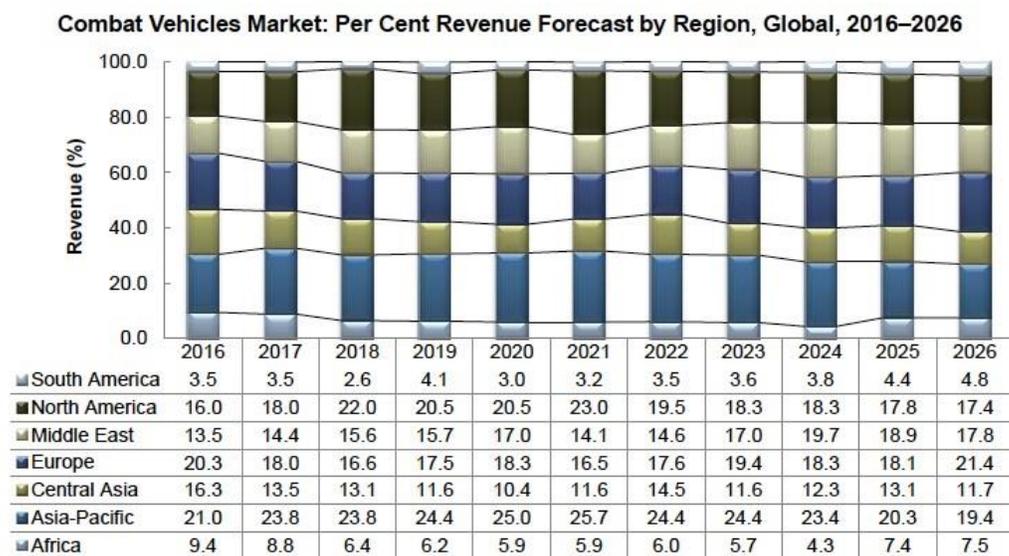
Regional Demand. Regional demand is highly nuanced by threat presentation, force condition, and national capital available for modernization in terms of economic capacity and political and social will. In Africa, \$13.47B is programmed for procurement of medium-weight Protected Patrol Vehicles (PPVs) to counter the rise of violent extremism and insurgent forces and to support localized production of IFVs and APCs in leading African states such as Algeria and Egypt.¹³ South America tells a nearly identical story with Brazil expecting to lead a continental investment of approximately \$8B.¹⁴

The Asia-Pacific is projected to nearly quadruple market opportunities over the next eight years, expecting \$47.34B for modernization of amphibious APCs, IFVs, and MBTs. While stalling economies like Malaysia and Indonesia are investing in advanced IFVs, larger developing defense industries in China, South Korea, Japan, Australia, and India are intently focused on producing heavier IFVs and MBTs. There is also a significant increase in demand

for new and upgraded amphibious CVs in Korea, Japan, and the Philippines. China has spent heavily to produce a large fleet of amphibious vehicles with high water speed capacity and Japan is investing to develop the same capability domestically. In central Asia, the vast majority of an estimated \$25.8B is expected to flow from Russia to drive MBT and heavy assault platform innovation, representing a national desire for global relevance. China, India, Israel, Korea, Russia, Singapore, and Turkey have also all invested in developing next generation tracked IFVs, bucking the global trend toward lighter combat vehicles, as exemplified by Israel's 60 ton heavy APC, Namer.¹⁵

This strategic competition is reflected closely in both North America and Europe, where \$39.16B and \$37.46B are programmed, respectively, for full spectrum, high-end development to balance the growing risk of conventional conflict.¹⁶ Generally speaking, Europe is moving toward smaller IFV fleets (quantity) and substituting tracked IFVs with wheeled APCs. Nevertheless, a number of "high end" tracked IFVs are being produced in Europe, such as Hagglund's CV90, KMW-Rheinmetall's Puma, and GDELS' Ajax, to replace obsolete models and compete in export markets. In North America the US continues to upgrade the Bradley IFV while Canada has shed most of its M113 APCs in favor of using wheeled CVs in the role of personnel carrier and IFV. The US Marine Corps is also making a large investment to acquire approximately 600 ACVs and to upgrade over 450 AAVs.

Finally, while Asia is the largest CV market, the Middle East represents the fastest growing market on the planet with \$33.19B allocated for CV procurement between 2016 and 2026.¹⁷ Localization and domestic industrial development is a key aspect of this expansion as countries such as Turkey look to secure domestic capacity for high-end CV production including IFVs and MBTs. **Figure 3** and **Figure 4** show total CV market revenue share by region, indicating very little change over the course of the 10-year forecast despite near and mid-term surges to recapitalize aging inventories in North America, Europe, and Asia.



Note: All figures are rounded. The base year is 2016. Source: Frost & Sullivan

Figure 3: Procurement (New) Revenue by Region¹⁸

CV SPENDING BY GEOGRAPHIC REGIONS		(2016-2025)	
Asia-Pacific		\$165.0	37%
Europe, Middle East, & Africa		\$194.0	44%
North America		\$76.2	17%
South America		\$8.1	2%
Total		\$443.3	100%

Figure 4: Total CV Spending by Region¹⁹

Market concentration and Major Players. Rapid innovation and commercial-to-defense technological transfer threaten to significantly shift the competitive field in the future combat vehicle market. That said, forecasts through 2026 indicate very little change in overall market concentration, indicating large OEM competition on the global scale. Despite growing competition in tier one and two suppliers, as well as on-going collaborative challenges such as the Franco-German NKDS (KMW-Nexter) 50-50 joint venture, General Dynamics (USA) will continue to dominate the MBT market, and BAE systems is expected to sustain just under half of the overall AAV and APC segments as well as 25% of the IFV market share.²⁰ Rheinmetall, Patria, KMW, and Iveco are other notable competitors in the future CV market. The following lists major combat vehicle firms around the globe. *Appendix A* includes the firms' main products, type of ownership, and the markets in which they compete.

<u>US-CANADIAN FIRMS</u>		<u>CHINESE FIRMS</u>	
GD Land Systems (US & CA)	Public	NORINCO (CN)	State
BAE Combat Vehicles (US)	Public	Poly Group Corporation (CN)	State
SAIC (US)	Public	<u>JAPANESE FIRMS</u>	
<u>EUROPEAN FIRMS</u>		Mitsubishi Defense Products (JP)	Public
Krauss-Maffei Wegmann (GE)	Private	Komatsu (JP)	Public
Rheinmetall Defense (GE)	Public	<u>KOREAN FIRMS</u>	
Nexter Systems (FR)	State	Hyundai Rotem Defense Systems (KR)	Public
Renault Truck Defense (Volvo) (FR)	Public	Hanwha Defense Systems (KR)	Public
BAE Systems Hägglunds (SE)	Public	Hanwha Land Systems (KR)	Public
BAE Systems Land (UK)	Public	<u>SINGAPORE FIRMS</u>	
Patria Oy (FI)	State	ST Kinetics (SG)	State
GD European Land Systems (AU,CH,ES)	Public	<u>ISRAELI FIRMS</u>	
Iveco – Oto Melara Consortium (IT)	JV	Israel Ordnance Corps, Tank Program Office	State
Iveco Defense Vehicles (IT)	Public	Elbit Systems (IL)	Private
Leonardo Defense Systems (IT)	Public	<u>SOUTH AFRICAN FIRMS</u>	
<u>RUSSIAN FIRMS</u>		Denal Land Systems (ZA)	
Kurganmashzavod (RU)	State	<u>INDIAN FIRMS</u>	
Military Industrial Company (RU)	Private	Defence R&D Organisation (DRDO)	State
Uralvagonzavod (RU)	State	Combat Vehicles R&D Establishment	State
<u>TURKISH FIRMS</u>		Ordnance Factory Board	State
FNSS (TR)	Private		
Otokar (TR)	Public		
BMC (TR)	Private		

Figure 5: Major Global CV Manufacturers²¹

Leading Firms by Military Vehicle Sales Revenue (2016-2025)	
NORINCO	\$55.0
General Dynamics	\$47.7
BAE Systems	\$24.4
Russian State Owned Industry	\$21.4
Oshkosh	\$16.4
KNDS (KMW + Nexter)	\$11.0
Iveco - Oto Melara Consortium	\$8.2
Hanwha	\$7.7
Hyundai	\$7.2

Figure 6: Leading Global CV Manufacturers²²

New entrants. Within the combat vehicle world export market, there have been several OEMs who are now new competitors to the traditional defense firms from the United States, Europe, Russia, and China. This builds upon a trend in the last two decades where many nations have developed defense industrial policies that forced foreign defense firms to enter into local production or joint ventures for indigenous combat vehicle production. In several countries, the combination of local production and dedicated local government funding allowed a small number of firms to grow the design and production capabilities for new combat vehicles.

This development of new defense firms capable of full production is notable within Singapore, Turkey, Republic of Korea, and Spain. These countries have ground vehicle defense firms that have the capabilities to design, produce, and sustain combat systems. Within Singapore, S&T Kinetics has developed the capability to design and produce infantry fighting vehicles, armored fighting vehicles, and artillery.²³ American SAIC has partnered with S&T Kinetics to bring some of its combat vehicle design to the North American Market. In the last two decades, Turkey's defense firms entered the world market as new exporter of main battle tanks (BMC), armored personnel carriers (Otokar & Nural), combat vehicle engines (MTU Turkey), and combat vehicle transmissions systems (Hema).²⁴ The Turkish combat vehicle firms will likely compete with Russian and Chinese firms in the Middle East and North African region. In the last two decades, the Republic of Korea sought self-reliance in defense manufacturing independent of the United States and now has the capability to design/produce K2 MBTs (Hyundai Rotem), self-propelled howitzers (Hanwha Group), and armored combat vehicles (Hyundai Rotem).²⁵ Hanwha Group has successfully sold their K9 artillery system to multiple European countries, which were traditional markets for American and European firms. The Spanish government has supported SAPA Transmissions' ability to develop and produce combat vehicle transmissions, and SAPA is a new transmission manufacturer entrant into the international defense market.

Combat Vehicle Market Forces. Demand for value is extremely high in the modern and future CV marketplace. Accordingly, there is intense competition to not only secure a majority stake of that value between established sellers and buyers, but to also defend against market alternatives and substitutes. Overall, buyer strength will remain high as state governments squeeze price-sensitive defense outlays from growing domestic demands. Buyers will continue to expand competitive acquisition policies domestically and abroad that further increase

transparency and broaden contract tenders for long-term, winner-take-all, fixed price, tranche contracts. In large countries with economic dependency on national champion OEMs, such as in France, nationalistic loyalties will reduce competitive forces in favor of suppliers and lead to negotiated contracts that shift value away from the buyer.

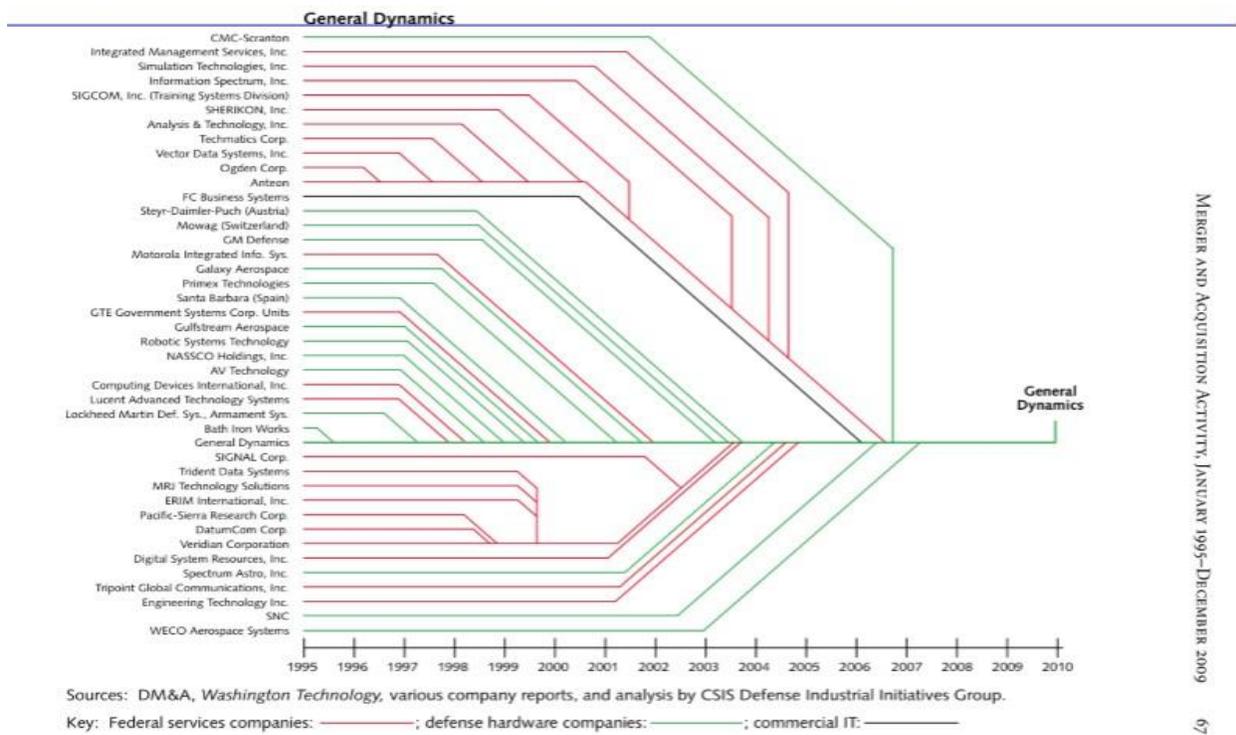
Seller strength will become increasingly nuanced as technological transfer from commercial developments reduces subcomponent dependencies and expands tier one and two competition. Suppliers that retain CV-critical intellectual property, such as MTU, Renk, Allison, and ZF, will continue to draw increased margins. In much the same way, the threat of new entrants will become increasingly significant in the production of lighter vehicles and development of dual-use subcomponents and supplies. In the case of large CVs, industrial know-how and extremely expensive capital investment will guard the traditional OEMs mentioned above. Price sensitivity will remain very high in the CV market as substitutions become increasingly viable in the future market. Technological advancements in survivability, mobility, and lethality make expensive CV programs easily replaceable as demonstrated in much of Asia, the Middle East, and Eastern Europe, where enhanced IFVs are pursued in place of traditional MBT ventures. Overall, the CV market will remain fairly competitive as localization trends offset national champion loyalties and technological developments invite increased participation in the market. Due to scale, joint ventures and collaborations will continue to keep market concentration high through 2026.

Notable Mergers & Acquisitions

Western Europe and the United States began a ground-defense-industry consolidation starting in the 1990s due to large reductions in defense spending, reduction in threats, and the requirement for increased local production of exported weapon systems. An additional policy change that impacted industry consolidation was the reduction in government funding of most western countries for ground combat vehicle development in the last several decades. The trend of governments desiring defense firms to fund their own product development accelerated the consolidation of the industry.

Figure 7 and **Figure 8** provide graphical representations of the defense industry consolidation over time. **Figure 8** shows that most of the European ground defense firms consolidated to one or two firms per country resulting in significant continental fragmentation and redundancy.²⁶

Figure 7 shows that the US ground vehicle defense firms consolidated into just two primary firms in the 1990s and 2000s.^{27 28}



MERGER AND ACQUISITION ACTIVITY, JANUARY 1995–DECEMBER 2009 67

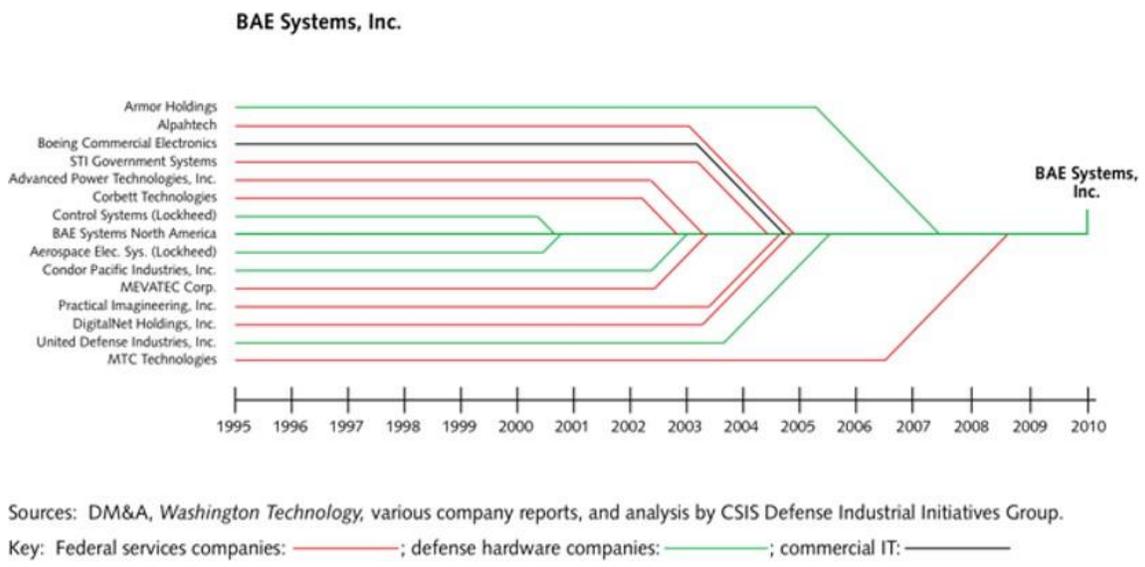


Figure 7: US Ground Defense Consolidation²⁹

Europe -- Land Combat Systems Consolidation

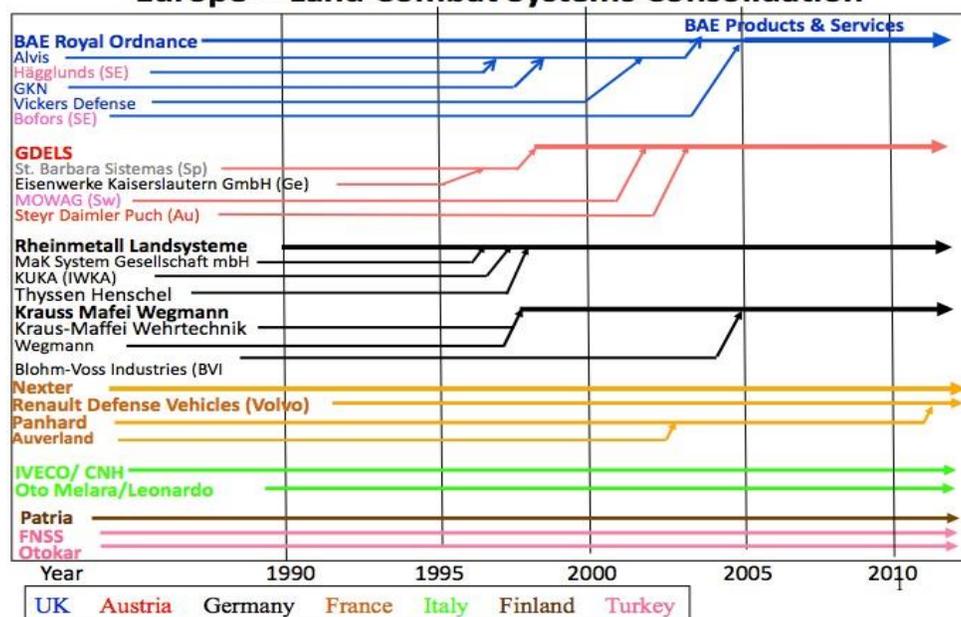


Figure 8: European Ground Defense Consolidation³⁰

Since most countries prefer domestically produced ground combat and tactical vehicles, further consolidation has not occurred within Europe. However, the Nexter-KMW merger may be the exception to this trend.³¹ Germany generally has strong export controls that limit the sale of combat vehicles to many countries for political reasons. France has a relatively relaxed export control policy. The merger between Nexter and KMW allows KMW access to France's permissive export environment.³² The interesting portion of this merger is the French government owns Nexter, and KMW is a private firm.³³ BAE and GDLS have similar arrangements that allow for a subsidiary in a different country to take advantage of national export control laws. China, Russia, and Turkey generally also have very permissive export control laws, and these countries are not currently looking for industry consolidation.^{34 35 36}

Combat Vehicle Product Review / Trends

The following review provides a baseline for industrial analysis, segmented by product type. For a complete definition of each combat vehicle category, please see [Appendix B](#). As referenced previously, [Appendix A](#) also provides a detailed account of each CV system in production, service, and known development organized by national headquarter and OEM.

Main Battle Tanks (MBTs). MBTs provide high-end combat capability for conventional forces with robust defense budgets. Despite low volume forecasts, the future MBT market represents \$71.4B in cumulative market value between 2016 and 2025. Top defense spenders are exploring possibilities for the next generation MBT and intense competition for innovative augmentation of current chassis is accelerating throughout the world.

In the past decade, MBTs have received limited investment, but tensions in Europe have restarted tank development programs.³⁷ Development is relatively slow, as many countries currently are purchasing or leasing second hand MBTs instead of purchasing new platforms. This is possible due to the large divestment of MBTs by the US, Netherlands, Germany, Russia,

and Australia.³⁸ MBT sales are the slowest growing segment of the combat vehicle market.³⁹ This indicates armies are not planning for a significant increase of MBTs in the next decade but will likely upgrade or replace current stocks. Even with slower sales, MBTs make up 23% of the ground combat vehicle market.⁴⁰ MBT sales are the primary driver of global combat vehicle sales, dominated by the Russian Armament Plan and the US M1A2 SEP3/4 upgrade program.⁴¹ In addition, there is potential for new MBT development within North America, Europe, China, and India. Recently, the Republic of Korea has developed a new K2 and Japan the Type 10 MBTs. Turkey is moving into production of their new Ataly tank, though they are still having some problems with their engine and transmission technology.⁴² There are two interesting divergent MBT development trends. Russia and Japan have moved towards smaller and faster MBTs in their next generation tank development while Western MBTs continue to increase in weight due to the focus on better survivability.⁴³ Additional tank development continues in active and passive protection systems focused on defeating RPGs and ATGM threats.

Table 2: Main Battle Tank Market⁴⁴

MBT Market: Top 5 Products, Global, 2016				
Platform	OEM	Main Specs	Status	Operators (non exhaustive)
M1 Abrams (SEP V2 1992)	General Dynamics (USA)	<ul style="list-style-type: none"> Weight: 65 tons Road Speed: 70 km/h Crew: 4 Engine: Honeywell 120 mm L/44 gun (main) (M1A2) 	In production (8,111 units in service in 2016)	USA, Australia, Egypt, Iraq, Saudi Arabia, Morocco
Leopard 2 (2A6 2007)	KMW (Germany)	<ul style="list-style-type: none"> 68 ton & 72 km/h Crew: 4 Engine: MTU 120 mm L/55 gun (main) (Leopard 2A6) 	In production (3,828 units in service in 2016)	Germany, Netherlands, Spain, Qatar, Canada, Chile, Austria, Denmark, Norway, Poland, Finland, Indonesia, Greece, Sweden, Switzerland, Turkey
T-90 (1995)	UVZ (Russia)	<ul style="list-style-type: none"> 48 ton & 60 km/h Crew: 3 Engine: UralTrac Ltd 120 mm L/43 gun (main) (T-90M) 	In production (2,489 units in service in 2016)	Russia, India, Azerbaijan, Turkmenistan, Algeria, Morocco, Bangladesh, Kyrgyzstan
T-80 (1976)	Kharkiv-KMBD (Ukraine)	<ul style="list-style-type: none"> 46 ton & 70 km/h Crew: 3 Engine: OJSC KADVI 125 mm L/45 gun (main) (T-80U) 	Production stopped in 1992 (1,132 units in service in 2016)	Russia, South Korea, Azerbaijan, Cyprus, Ukraine, Belarus, Bangladesh, Yemen, Pakistan, China, Kazakhstan
AMX Leclerc (1992)	Nexter Systems (France)	<ul style="list-style-type: none"> 57.4 ton & 72 km/h Crew: 3 Engine: Wärtsilä 125 mm L/52 gun (main) 	Production on hold (794 units in service in 2016)	France, United Arab Emirates

Infantry Fighting Vehicles (IFVs). Current efforts to expand the IFV market have yielded significant innovation and product development. Cumulatively, \$95.1B is programmed for procurement between 2016 and 2025 with a noticeable decrease in market concentration as more firms win IFV contracts.⁴⁵ As shown below, advancements in mobility and lethality have increased the combat capabilities of modern and future IFVs enabling them to be considered for high-end roles in smaller defense budgets, likely increasing sales in the near future. Generally, IFVs continue to increase in weight, growing from 30 to 40 tons, and a few countries are opting to replace older MBTs with advanced IFVs (Belgium and Netherlands).⁴⁶

Table 3: Armored Infantry Fighting Vehicle Market
AIFV Market: Top 5 Products, Global, 2016

Platform	OEM	Main Specs	Status	Operators (non exhaustive)
M2 Bradley (1981) Tracked	BAE Systems (UK) Formerly United Defence (USA)	<ul style="list-style-type: none"> Weight: 27.6 tons Road Speed: 56 km/h Crew: 3+ 6 troops Engine: Cummins 25 mm M242 Chain Gun (main) 	Production stopped in (6,959 units in service in 2016)	USA, Saudi Arabia
Puma (2009) Tracked	KMW & Rheinmetall Land Systems GmbH (Germany)	<ul style="list-style-type: none"> 43 tons & 70 km/h Crew: 3+ 6 troops Engine: MTU 30 mm MK30-2/ ABM autocannon (main) 	In production (100 units in service in 2016)	Germany
CV-90 (1993) Tracked	BAE Systems (UK) Formerly Hägglunds AB (Sweden)	<ul style="list-style-type: none"> 35 tons & 70 km/h Crew: 3+6 troops Engine: Scania 40 mm Bofors Autocannon (main) 	In production (1,015 units in service in 2016)	Sweden, Norway, Finland, Denmark, Netherlands, Switzerland, Estonia
BMP-3 (1987) Tracked	Kurganmashzavod (Russia)	<ul style="list-style-type: none"> 21 tons & 72 km/h Crew: 3 + 7 troops Engine: OJSC Barnaultransmach 100 mm gun/launcher 2A70 (main) 	In production (2,878 units in service in 2016)	Russia, Azerbaijan, Cyprus, Indonesia, Greece, Ukraine, Algeria, Morocco Kuwait, Saudi Arabia, Sri Lanka, Turkmenistan, United Arab Emirates, Venezuela
Piranha III (1994) Wheeled	General Dynamics (USA) Formerly MOWAG (Switzerland)	<ul style="list-style-type: none"> 18 tons & 97 km/h Crew: 2+12 /variants Engine: MTU/variants 105 mm gun (main) 	Production on hold (4,044 units in service in 2016) (Stryker and LAV III included)	USA, Canada, Belgium, Brazil, Denmark, New Zealand, Iraq, Spain, Romania, Ireland, Switzerland, Botswana, Peru

Armored Personnel Carriers (APCs). Spending is forecasted to amount to \$77.1 billion for the highly competitive APC market over the 2016 and 2025 time period.⁴⁷ Modern developments and future programs make these core products increasingly mobile and protected while similar market forces will work in favor of buyers to keep prices down while performance continues to rise. Current trends to expand modular, family of vehicles designs are also increasing multi-role market potential for APCs.

Until recently, many European countries replaced traditional APCs and IFVs with wheeled APCs to reduce production and sustainment costs.⁴⁸ Since 2008, the Boxer wheeled APC, using a modular payload system, has been very successful in worldwide sales. Some countries are even placing IFV turrets on wheeled APCs as an alternative to more expensive IFVs. The APC procurement forecast will likely remain stable for the next 10 years, driven primarily by US Armored Multi-Purpose Vehicle (AMPV) production.⁴⁹ Recently in Europe, tracked APCs are gaining more consideration because of an increase in tensions from Russian operations in Ukraine and Crimea. As countries invest more in APCs and move away from peacekeeping/counter insurgencies, Protective Patrol Vehicles (PPV) (MATVs, MaxxPro, JLVT, etc.) sales will likely decline over the next decade.⁵⁰ Countries receiving second hand PPVs, divested by the US, will further suppress new PPV purchases.⁵¹

Table 4: Armored Personnel Carrier Vehicle Market
APC Market: Top 5 Products, Global, 2016

Platform	OEM	Main Specs	Status	Operators (non exhaustive)
Boxer (2008) Wheeled 8x8	ARTEC (Germany-Netherlands)	<ul style="list-style-type: none"> • 36.5 tons & 103 km/h • Crew: 3+ 8 troops • Engine: MTU • 155 mm/52-calibre gun(main) 	In production (3,828 units in service in 2016)	Germany, Netherlands, Lithuania
Patria AMV (2001) Wheeled 8x8	Patria (Finland)	<ul style="list-style-type: none"> • 27 tons & 100 km/h on road/ 10km/h in water • Crew: 3+12 troops • Engine: Scania • 105 mm gun (main) 	In production (1,529 units in service in 2016)	Sweden, Norway, Finland, Denmark, Slovenia, Croatia, Poland, South Africa, United Arab Emirates
BTR-82 A (2012) Wheeled 8x8	Military Industrial Company (Russia)	<ul style="list-style-type: none"> • 15.4 tons & 100 km/h on road/ 10 km/h in water • Crew: 3 + 7 troops • Engine: Kamaz • 30 mm dual-feed automatic cannon (main) 	In production (350 units in service in 2016)	Russia, Azerbaijan, Kazakhstan
Pandur II (2012) Wheeled 8x8	General Dynamics (USA) Formerly Steyr-Daimier-PuchSpezialfahrzeug GmbH (Austria)	<ul style="list-style-type: none"> • 22 tons & 105 km/h • Crew: 2+ 12 troops • Engine: Steyr Motors/Cummins • 105 mm gun (main) 	In production (794 units in service in 2016)	Portugal, Czech Republic, Indonesia (8x8 operators only)
Pars (2005) Wheeled 8x8	FNSS Defence Systems Inc. (Turkey) JV between BAE Systems and Nurol Holding	<ul style="list-style-type: none"> • Weight: 24.5 tons • Road Speed: 100 km/h • Crew: 2+ 12 troops • Engine: Caterpillar • 25 mm gun turret (main) 	In production (407 units in service in 2016)	Turkey, Malaysia (DefTech AV8 variant)

Reconnaissance Vehicles. Reconnaissance vehicle sales are slightly decreasing as PPVs and autonomous air and ground systems are displacing traditional reconnaissance vehicles.⁵² One exception to this trend is the likely increase in reconnaissance platform purchases by UAE, Turkey, and Saudi Arabia.⁵³

Armored Engineering and Recovery Vehicles. Armored Engineering and Recovery Vehicles will likely see growth as a complementary product to MBTs. Defense firms often use new MBTs to provide the chassis for replacement engineering vehicles. Currently, US and Germany vehicle manufacturers have more capable engineering and recovery vehicles.⁵⁴ If trends of increasing weight of MBTs continue, there will be a requirement to upgrade MBT recovery vehicles systems. In the long term, advancements in robotic arms and remote repair systems will likely impact future engineering and recovery vehicle developments.⁵⁵

Self-Propelled Artillery. Many countries have started movement away from tracked toward wheeled self-propelled howitzers.⁵⁶ Tracked self-propelled howitzers make up most of the fielded systems, but many of the future artillery competitions are including wheeled artillery systems. Wheeled artillery systems cost less to procure and sustain, and they do not require heavy equipment transport for long distance movements. French Nexter Systems has sold the wheeled CEASAR 155mm/52 caliber to France, Indonesia, Saudi Arabia, and Thailand.⁵⁷ India is currently holding the largest wheeled self-propelled procurement competition, and Nexter CEASAR and the Israeli Soltam Systems 155mm/52 caliber wheeled artillery systems are in the running.⁵⁸ Denel Land Systems has sold the G6 155mm/45 caliber wheeled artillery system to the South African National Defense Force, Oman, and UAE for many years.⁵⁹ Sudan has taken Russian D-20 122mm towed artillery and mated it with a 6 x 6 wheeled platform called the

Khalifa.⁶⁰ Tracked self-propelled artillery systems such as the KMW PzH2000, Russian 152mm Koalitsiya, and Hanwha K9 are still in production with India recently purchasing 100 K9s.⁶¹

Combat Vehicle Technology / Trends

Combat vehicle modernization efforts must solve the “combat vehicle challenge;” that is, designing combat vehicles that protect Soldiers against threats and deliver precision lethality, while providing both tactical mobility and global responsiveness within the limitations of vehicle cost and weight. Cost and weight factors limit the attributes of protection, lethality, and mobility possessed by any combat vehicle.⁶²
General Daniel B. Allyn (Ret)

Mobility, lethality, survivability, and sustainability have been major drivers of CV design and capabilities since the first British “Land Ships” entered the Battle of Flers-Courcelette in 1916. Decades of technological improvements and new developments in engines, transmissions, running gears, hulls, turrets, guns, protection systems, and vehicle electronics (vetronics) have made today’s combat vehicles more capable and reliable than previous models. This section will provide global trends in CV technologies as-well-as a brief glimpse into some of the CV technologies of tomorrow.⁶³

While it is difficult to prioritize any one CV function above the other, it can be argued that there is a logical sequence of their roles in meeting CV missions. This sequence will be the order that the trending technologies are discussed: 1) Without propulsion and mobility/maneuverability the vehicle can’t get to the fight and move once there; however, 2) if the vehicle is not survivable, it won’t fight for long; and, 3) once you’ve achieved these, the vehicle must be able to do its job. Finally, the vehicle must be sustainable, preferably as easily and intelligently as possible. The following paragraphs will highlight technology trends in each of these areas, prioritized by the discussed mission sequence.⁶⁴

Mobility and Maneuverability: Trends in propulsion systems and autonomy

Propulsion Systems. CV mobility and maneuverability primarily consists of the propulsion system, the suspension, tread type, crew visibility, autonomy, and vehicle weight. Current CV platforms are primarily designed around a specific engine, transmission and cooling system combination, or power pack. Engines are typically diesel and are rated by their power to density ratios, or size versus power output. The goal is “the smaller the better” without compromising power output. The German firm MTU, a business unit of Rolls Royce Power Systems, has made some of the most technological advances in diesel engine performance in the industry. MTU’s series 890 High Power Density (HPD) engine achieves a reduction in weight and volume of approximately 60% compared to existing modern CV engines with the same power output. It also possesses an unprecedented weight-to power ratio of 0.94 kg/kW. MTU has made compatible advancements with the cooling system.

While investments to improve diesel engine performance in CVs are a significant part of R&D in the CV industry, hybrid-electric systems are promising to be the next advancement in CV propulsion technology. The same MTU designed HPD engine described above was originally designed to power a CV hybrid-electric power train. This configuration has the engine driving a generator which in-turn provides electricity to electric drive motors that may be located

near where a traditional transmission would mate to a transfer case, or wherever convenient for the vehicle design.⁶⁵ The hybrid-electric system's electrical power generation can also provide power requirements for new weapon designs like lasers, electromagnetic rail guns, and to the increasing electrical requirements of avionics.

Autonomy. Unmanned autonomous technologies are being considered for all makes and models of CVs throughout the world. The US Army is pursuing autonomous systems as an initiative to improve the combat effectiveness of their future force. Their solutions will focus on human-machine collaboration tailored to the CV mission. Autonomously-enhanced teams buy back time and space for battlefield leaders providing them greater tactical and operational bandwidth. These include increased reaction speeds and greater standoff distances. Autonomous CVs keep soldiers safe, provide more room in the vehicles for offensive, defensive, power, and protection systems. Almost every major firm in the global CV market is pursuing autonomous technology. Driven by major advancements in the commercial sector's automotive industry, autonomy is finding its way into military supply vehicles. Success in the CV sector is becoming more evident as autonomous CV prototypes are being discussed and displayed publicly.⁶⁶

It is impossible to discuss autonomous CVs without the subject of artificial intelligence (AI). AI plays a critical role in the development of autonomous systems as it improves the ability for autonomous CV platforms to operate successfully in tasks such as off-road driving and analyzing massive amounts of data intended to enhance human decision-making. Additionally, AI is being considered for assisting in the development of mission parameters, enhancing rules of engagement decisions, and conducting terrain analysis.⁶⁷

Another trending technology for CVs are rubber tracks, or "band track". While the original goal of the technology was to reduce vehicle weight, it came with several other cross-cutting benefits. In addition to its significant weight savings over steel track treads, band track reduce noise, improve the crew's comfort, and reduces vibration and shock perturbations throughout the vehicle. The latter not only benefits the crew but improves the life expectancy of electrical systems.

Denmark and Norway conducted operational testing on the BAE designed and produced CV90 with band tracks and found the following results.⁶⁸

- Vibration levels reduced by 50-65%.
- Noise levels were reduced by 6-10 decibels (dB). TACOM/TARDEC study on band tracks for M113's showed the internal noise levels dampening in heavy truck cabins.
- 30% lighter than steel tracks.
- More durable with twice the life expectancy of steel tracks.
- Better fuel economy due to reduced rolling resistance. M113A3 with band tracks had 67% less rolling resistance than the T130 tracks.

While the following list of CV technologies is not discussed in detail in this section, they are additional examples of advancing mobility and maneuverability technologies for CVs.

- Decoupled running gear: Weight reduction, modular for easier removal & replacement R&R, and provides additional protection
- Adaptive suspension: Auto-adjusting stability improvements for varying speeds and terrain
- Transmissions: Significant improvements in automated manual designs, controversial increases in the number of gears, and tracked vehicle cross drive steering
- Glass: Improvements in "multi-hit performance" and transparency for better crew visibility

Survivability: Trends in Combat Vehicle hull designs and active protection systems

Hull Designs. Traditional hull designs are based on passive armor technology. Typically, CVs will have a base hull material made from either steel or high strength aluminum made up of specially welded panels. This provides the CV with its basic protection, but its main function is to provide structural integrity to the CV. Add-on armor is used to provide the bulk of the protection. These are usually very thick and heavy designed to prevent penetration from a variety of potential threats. However, with the high-tech penetration capabilities of modern threats, this brute-force technology can significantly increase the vehicle's weight, negatively affecting its mobility. This technology seems to have reached its limit for effectiveness.⁶⁹ There are two additional passive technologies that are currently in various stages of development designed to dramatically improve the survivability performance of CV hulls, molded hull forms and composite ceramic hull materials.

The Aluminum firm Alcoa has a contract with the US Army to design a new hull for CVs that has greatly increases survivability against improvised explosive devices (IED), reduces vehicle weight and, most importantly, saves soldiers' lives. The new technology is in the ability to shape the entire hull out of one continuous piece of aluminum instead of multiple welded panels.⁷⁰ A second technique employs the same add-on protection commonly used with today's CVs, however the add-on material is made of a ceramic impregnated steel composite that is lighter than the traditional treatment and has greatly improved "multi-hit" performance. Light Improved Ballistic Armor (LIBA) is currently available and is developed by Mofet Etzion.⁷¹

Active Protection Systems (APS). The other technology recently developed to increase CV survivability involves an array of integrated systems. These integrated technologies are designed to increase survivability from armor penetrating warheads like the RPG-7V, which can easily penetrate up to 300mm of armor. Possible due to the processing power of modern day computers, these systems detect the incoming threat using radar and/or a laser detection system and launch countermeasures to directly destroy the threat when it is just yards from impacting the CV. These systems do not typically directly impact the incoming threat, but explode in its vicinity countering the percussion and completely minimizing any direct and percussive impact with the CV.

This technology is also known as Active Defense Suites (ADS). Russia developed the ARENA system in the 1990s, one of the earliest designs of this type of technology. Since then, other systems have been developed by Deisenroth Engineering's (IBD) Advanced Modular Protection-Active Defense System (AMP-ADS), Saab's Land Electronic Defense System, Israel Military Industries' (IMI) IRON FIST, and Rafael's TROPHY system.⁷²

While the following list of systems were not detailed in this section, they are additional examples of advancing survivability technologies for CVs.

- Electrified hulls: Improves protection from RPGs when the electrified hull causes it to explode before penetrating the CV
- Energy absorbing structures: While much of this technology is being focused on the exterior of the CV, seat improvements are utilizing them to protect the crew from blast and ride injuries
- Detection avoidance: Technologies such as active and passive camouflage and electromagnetic signature reduction are being
- Cyber hardening: Technologies that prevent the compromise of CV networks and operating systems
- Nano materials: Very similar technology to the composite-ceramic material discussed in this section, but with tailorable plasticity with very high strength and ductility properties

Lethality: Trends in unmanned turrets/remote weapon stations and hypersonic munitions

Manned turret systems have been the traditional configuration for CVs, with crew members performing their mission from within the turret. However, this exposes these personnel to the asymmetric threat from Improvised Explosive Devices (IED) and Rocket-Propelled Grenades (RPG). One trending solution is to have the crew perform their functions remotely allowing them to remain within the main body of the vehicle and improve their survivability. Another advantage of the unmanned turret is that they are inherently more compact giving the CV a lower profile making it less detectable on the battlefield. Configuring CVs with remotely operated weapon stations has been a trending technology that first started about ten years ago.⁷³

There are continuing developments in ammunition and gun technologies that are advancing the lethality of CVs. One of the latest advancements involves the US Army Howitzer. It has been outfitted with a super high-speed, high-tech, electromagnetic Hyper Velocity Projectile that was initially developed as a Navy weapon. While still under test, it is expected to give the US Army the ability to shoot down incoming ballistic missile threats.⁷⁴

Sustainability: Modular designs

The concept of modularity can cover a very broad spectrum of CV designs. At one end of the spectrum there is the use of common components across a variety of CV variants, or vertical modularity. At the opposite end of the spectrum there are CVs that are designed to be reconfigured in theater that give the CV an entirely different capability or mission. The benefits are lower costs due to commonality and the flexibility of a base platform to perform more than one mission. This type of modularity, called horizontal modularity, also allows for much easier the integration of new technologies as the modules can be removed, modified or completely replaced with the new technology.

Rheinmetall's German-Dutch produced Boxer APC and the United Kingdom's Cameleon IV440 are both modern horizontally modular CVs that can be modified in the field. The Boxer is a very heavy, 36-ton CV that has several mission modules that can be interchanged in the field to accomplish different functions. These mission modules can be interchanged in an hour to create an armored personnel carrier, an infantry fighting vehicle, or an ambulance. Seven configurations are available for the IV440. These include patrol vehicles, weapons platforms, fuel bowsers, and power generators, with more being developed. The base platform includes a hydraulic system to enable rapid platform reconfiguration. Module changeover can be accomplished by one person in only one minute.⁷⁵ Additionally, modular designs reduce multiple supply chains and training for mechanics.

Future Combat Vehicle Science & Technology

There are two next generation combat vehicle science & technology (S&T) programs that will help define CVs of tomorrow; the US Army's Next Generation Combat Vehicle (NGCV) and the Israeli Defense IDF's CARMEL Future Combat Vehicle. These S&T programs are planning to produce a vehicle for fielding in the second half of the next decade.

The US Army is starting with a set of six experimental prototypes for their CV of tomorrow. Two will be manned and four robotic. Brigadier General David Lesperance is the leader charged with laying out the Army's plan to develop and field the NGCV. In an interview with Jen Judsen of Defense News he stated "We are looking at an NGCV that really gives us leap-ahead capability from that which we have now. We are looking at critical-enabling and

potentially disruptive capability that includes a deep dive at reducing weight and shifting the size-weight-power paradigm.”⁷⁶

The Army’s Tank Automotive Research Center (TARDEC) is utilizing Other Transactional Authority (OTA), an innovative contracting vehicle; to tap into innovative commercial technologies and get them into the NGCV.⁷⁷ Autonomy, remote control, cyber security, passive and active protection, and mobility are all focus areas for the NGCV. These are expected to include nanocomposites for ballistic protection, advanced propulsion systems, modularity, and innovative logistics solutions.⁷⁸

The IDF has a very clear vision of their future combat vehicle in their CARMEL program. They have created an extremely high-quality video game-like animated production of the vehicle and the advanced technologies their CARMEL program will incorporate into their future CV. This program will develop a cooperative active protection system that will operate across multiple CVs via a state-of-the-art, cyber-hardened network. The idea is that the threat detection and active protections systems of CVs in a formation will be networked into one active protection system that will be greater than the sum of their parts providing optimal detection and protection. This futuristic CV will also have improvised explosive device detection and neutralization, signature management to reduce detectability, and will have a hybrid electric drive. Its armor is expected to be equally advanced with greater protection and minimal weight penalties.⁷⁹



Figure 9: Artist Rendition of the CARMEL CV

Like the Joint Strike Fighter’s invisible fuselage, the CARMEL program is planning a see-through hull, also known as “closed-hatch operations”, to give the tanks Commander unprecedented visibility and safety. Along with some of the other CARMEL driven technologies, the closed-hatch technology is expected to be incorporated into the Israeli Merkava Mark IV tank in the next three to five years.⁸⁰

Conclusions

Today we find ourselves in very unique circumstances. The world may be as dangerous as it has ever been; and sophisticated technologies have made many of the world’s current combat vehicles vulnerable to new weapons. Many nations combat vehicles fleets are beyond their expected service lives and many are seeking to upgrade their fleets or purchase new combat vehicles to deal with the latest threat technologies. In the long run, an individual nation’s security needs, defense strategy, geography, defense industrial base capability, and most importantly its fiscal resources will drive how a nation decides to equip its ground forces. Although, there are no universal trends within the global combat vehicle market, the factors listed above drive buying decisions around the world.

In the near term, we expect that nations will continue to seek improvements in their fleet’s mobility, protection, and lethality while trying to reduce the amount of resources required

for sustainment. Over the next ten years, we believe that global defense spending will trend slightly higher. For the first time since the 2008-2009 global recession, the world is experiencing economic growth across the board with few exceptions supporting greater defense outlays. The world's two largest buyers of combat vehicles (US and Europe) will attempt to counter Russia's aggression and China's rise by modernizing their current fleets. We also expect greater spending in Asia, (Korea, Japan, India) based rising tensions and their efforts to support their growing domestic combat vehicle firms. Lastly, we anticipate the recent trend of consolidation in the industry will slow as increasing defense budgets provide enough business to sustain current firms.

Within budgetary constraints, nations will seek to adopt or integrate technology faster than ever before to maintain or gain an advantage over their adversaries. Technological advances in mobility, lethality, and survivability have the potential to usher in whole new fleets of combat vehicles. In particular, autonomous and manned-unmanned teaming and the increasing lethality of today's munitions may render the current platforms cost-ineffective, defenseless, or even obsolete. This could cause individual countries to choose greater quantities of lower cost substitutes; make money-saving choices between wheel and track fleets, or make trade-offs between mobility, lethality, and survivability when making new purchases. Individual nations will also protect their domestic industry and technological advances with stricter import/export controls to include greater cyber security requirements for combat systems and their manufacturers.

Notwithstanding budgetary constraints, technological advances, industry consolidation, or strict regulatory inhibitors; combat vehicles and the market that produces them will always play a leading role in the global defense market. Nations need their ground forces to have mobility, firepower, and protection whether they are used for defensive or offensive operations. And, regardless of their future form; combat vehicles remain an enduring, necessary, and indispensable capability.

APPENDIX A: COMBAT VEHICLE FIRMS, PRODUCTS, AND MARKETS

Firm Name	Type	Key Products	Primary Markets	Secondary Markets
EUROPEAN FIRMS				
<u>Krauss-Maffei Wegmann (GE)</u>	Private	Leopard 2 MBT, Puma IFV, Boxer APC, PzH 2000, Fennek Recon Veh, Dingo	GE, EU, TR	Asia, AU, SA
<u>Rheinmetall Defense (GE)</u>	Public	Puma IFV, Boxer APC, Fuchs APC	GE, EU, TR	AS, AU, ME
<u>Nexter Systems (FR)</u>	State	LeClerc, VBCI IFV, CEASAR SPH	FR, EU, ME	AF, AS, ME
<u>Renault Truck Defense (Volvo) (FR)</u>	Public	VAB APC, Protected Vehicles	FR, EU, ME	AF, NA, SA
<u>BAE Systems Hägglunds (SE)</u>	Public	CV-90, BvS10 Armored ATV, Archer SPH	SE, NO, FI	EU, NA
<u>BAE Systems Land (UK)</u>	Public	Challenger 2 MBT, Warrior IFV, CVR(T), AS-90 SPH, Terrier Combat Engineer Vehicle	UK, ME	
<u>Patria Oy (FI)</u>	State	AMV (Armored Modular Vehicle) IFV/APC	FI, PL, EU	ZA, ME
<u>GD European Land Systems (AT, CH, SP)</u>	Public	Ajax/Pizzaro/Ulan IFV, Piranha APC, Pandur APC, Eagle	CH, DK, ES, GE, RO, UK	EU, ME
<u>Iveco – Oto Melara Consortium (IT)</u>	JV	Arite MBT, Dardo IFV, Freccia IFV, Centauro MGS, VBTP Amphib Vehicle, Puma Patrol Veh	IT, BR, ME	Asia, SA
<u>Iveco Defense Vehicles (IT)</u>	Public	Centauro, SuperAV & VBTP Amphib Veh, LMV	IT, BR, ME	Asia, SA
<u>Leonardo Defense Systems (IT)</u>	Public	Turrets, CV technology	IT, EU	
RUSSIAN FIRMS				
<u>Kurganmashzavod (RU)</u>	State	Kurganets-25 IFV, BMP-1, BMP-2, BMP-3 IFVs, BREM-L Armored Recovery Vehicle	IN, DZ, VN	MENA, SA
<u>Military Industrial Company (RU)</u>	Private	K-17 Bumerang IFV, K-16 Bumerang APC, BTR-82A, BTR-80 and BTR-80A APCs; BREM-K armored recovery vehicle	IN, DZ, VN	MENA, SA
<u>Uralvagonzavod (RU)</u>	State	T-72, T-90, T-14 Armada MBTs, T-15 Heavy IFV, BMPT Tank support fighting vehicle, IMR-2MA Combat engineer vehicle	IN, DZ, VN	MENA, SA

TURKISH FIRMS				
FNSS (TR)	Private	ACV-15 & ACV-19 Armored CVs, Kaplan IFV, Kaplan Med TankFoV, PARS Family of Wheeled CVs, & turrets	TR, Asia	MENA
Otokar (TR)	Public	Altay MBT design, Tuplar IFV, Arma 6x6 and 8x8 Wheeled CV, MRAP	TR, MENA	
BMC (TR)	Private	Altay production, Kirpi MRAP, Protected vehicles	TR, MENA	EU, SA
US-CANADIAN FIRMS				
GD Land Systems (US & CA)	Public	M1 MBT, Stryker FoV, LAV FoV	NA, MENA	AU NZ
BAE Combat Vehicles (US)	Public	Bradley IFV, M109A7 SPH, M992A2, M88 Recovery Veh, AMPV, M113 FoV	NA, MENA	
SAIC (US)	Public	AAV-SU, ACV, MPF, NGCV (S&T)	NA	
CHINESE FIRMS				
NORINCO (CN)	State	VT4 MBT (MBT-3000), MBT-2000, Type 98 MBT, Type 99 MBT, ZBD04 IFV, ZTD-05 AAV, Type 04/09 IFVs, VN1 8x8 APC, Type WZ506 airborne assault vehicle, PLZ-05 SPH, PLL-05 assault gun, PHL-03 MLRS	PK, Asia MENA	AF, SA
Poly Group Corporation (CN)	State	Type 07 8x8 APC and Type 06 4x4 APC	AS, MENA	AF, SA
JAPANESE FIRMS				
Mitsubishi Defense Products (JP)	Public	Type 10 & 90 MBTs, Type 16 Tank destroyer, Type 89 IFV, Type 73 APC, Type 99 SPH	JP	US, Asia
Komatsu (JP)	Public	Type 96 APC, Type 82 C&C Veh, New 8x8 APC under development	JP	Asia
KOREAN FIRMS				
Hyundai Rotem Defense Systems (KR)	Public	K2 MBT, K1 MBT, K806/K808 Wheeled Armored Vehicles, Future CV (S&T)	KR, TR, Asia	MENA, SA
Hanwha Defense Systems (KR)	Public	K21 IFV, K200 IFV, Missile Launcher Veh, Barracuda 4x4	KR, Asia	
Hanwha Land Systems (KR)	Public	K9 Thunder SPH, K10 Ammo Carrier, Wheeled Combat Robot	KR, EE, FI, IN, NO, TR	Asia, MENA

SINGAPORE FIRMS				
ST Kinetics (SG)	State	Bionix IFV, Terrex IFV, Broco Armored ATV	SG, NA	Asia
ISRAELI FIRMS				
Israel Ordnance Corps, IMOD Tank Program Administration (MANTAK)	State	Merkava MBT, Eitan APC, Namer Hvy APC, Nakpadon APC, Nagmachon APC, Achzarit Hvy APC, Puma Engineer Veh	IL	IN
Elbit Systems (IL)	Private	ATMOS 155mm/52 caliber truck-mounted howitzer	IL	IN
INDIAN FIRMS				
Defence D&D Organisation (DRDO) Combat Vehicles R&D Estab Ordnance Factory Board	State	Arjun MBT Co-Production: T-90S, T-72M, BMP-2, Catapult SPH,	IN	
SOUTH AFRICAN FIRMS				
Denal Land Systems (ZA)	State	Badger (Patria AMV)	ZA, AF	

APPENDIX B: VEHICLE DESCRIPTIONS

Main Battle Tanks (MBT) refers to tracked heavy combat vehicles used to perform direct fire support roles, with a main tank gun and weight of more than 45 tons. They also include engineering, recovery, bridge layer and obstacle breach variants based on a main battle tank chassis.⁸¹

Infantry Fighting Vehicles (IFV) are defined as tracked medium-weight combat vehicles of 30 to 45 tons, with firepower provided by a medium caliber gun. These vehicles are used to carry infantry into the battlefield and provide fire support. IFVs also include reconnaissance and fire support variants.⁸²

Armored Personnel Carriers (APC) are armored vehicles designed to carry troops to and from the battlefield. It has limited firepower options and typically have a combat weight in the range of 15 to 35 tons. APCs can be tracked or 8x8, 6x6, and 4x4 wheeled vehicles in different roles and variants.⁸³

Amphibious Assault Vehicle (AAV) are operated in surface assault missions and amphibious troops transport often in jungle and maritime environments. Most of them are tracked.⁸⁴

Light Multirole Vehicles (LMV) are a family of light armored 4x4 vehicles weighing between five and 12 tons. They are used in liaison, patrol, utility, command and reconnaissance roles.⁸⁵

Mine Resistant Ambush Protected (MRAP) vehicles are a family of armored vehicles capable of providing increased crew protection and vehicle survivability to counter battlefield threats such as improvised explosive devices (IEDs), mines and small arms. These counter IED vehicles include, but are not limited to, the US MRAP family of vehicles, and other developments of the same class of vehicles in countries such as South Africa, India and others.⁸⁶

Self-Propelled Guns are a form of self-propelled artillery and is usually used to refer to artillery pieces such as howitzers. Self-propelled guns are mounted on a motorized wheeled or tracked chassis.

Tactical Trucks include all support vehicles (light, medium and heavy) that perform logistics and support roles. They range from five-ton general purpose trucks and medium lift carriers to 70-ton Heavy Equipment Transporters (HET), which are used to carry main battle tanks.⁸⁷

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