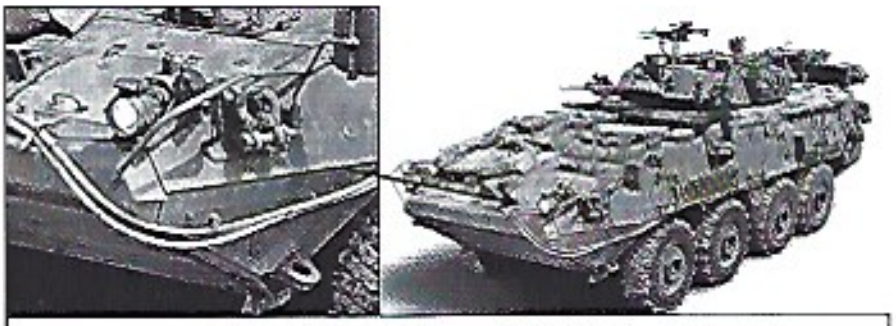


Photos Courtesy Program Manager Brigade Combat Team

Figure 11. The MEXAS™ armor panels mounted on the Canadian LAV III APC

5.6 General Motors Defense Systems

The U.S. Army has initiated a major development program to transform the existing family of heavy vehicles to a lighter, more agile and deployable force. The Future Combat System (FCS) is planned for fielding by 2015. As part of the transformation, a contract to purchase an interim family of light vehicles under the Interim Brigade Combat Team has been awarded to GM GDLS Defense Group L.L.C. of Sterling Heights, MI [24]. Among the many variants is the Infantry Combat Vehicle (ICV) shown in Figure 12. Based on the LAV III chassis and hull, the ICV mounts a version of the MEXAS™ system of IBD. The similarities in the design and mounting are visible.



Photos Courtesy Program Manager Brigade Combat Team

Figure 12. The ICV of the Interim Brigade Combat Team utilizes the IBD MEXAS™ applique

The GM GDLS contract indicates the ICV is to have overhead and all around protection for the squad and crew from 152-mm Artillery high explosive airburst at an undisclosed distance from and above the vehicle. The ICV shall also provide integral 360° and overhead squad and crew protection from 7.62-mm AP threats and 360° squad and crew protection from 14.5-mm AP ammunition, both fired from undisclosed impact conditions. The ICV shall also provide the capability to mount add on armor packages to protect against hand held shaped charge warheads up to and including the RPG-7.

5.7 Textron Marine and Land Systems

Textron Marine and Land Systems of New Orleans, LA is the prime fabricator for two interesting applications of ceramic composites, the U.S. Army Armored Security Vehicle (ASV) and the Marine Corp Landing Craft, Air Cushion (LCAC) vehicle (Figure 13). On the initial vehicle procurement, the ceramic composite armor kit on the ASV was produced by Simula Safety Systems of Phoenix, AZ,

Extensive testing of AAAV armor at tight multi-hit distances was required for engineering development and Government validation tests. The AAAV SURMAX™ side armor panel on the left of Figure 16 is a typical validation target, after four partial penetrations, three with 14.5-mm AP and one with a simulated artillery fragment. Shots 1 and 2 are located 101-mm (4") apart. Shown on the right is a multi-hit test panel with ten 0.50-caliber AP impacts for the AGMS, all partial penetrations with the tenth shot at a distance of 76-mm (3") from one previous shot.



Figure 16. Ballistic Multi-hit Qualification Tests for the AAAV and the AGMS

5.9 Simula Incorporated

Simula Incorporated, Phoenix, AZ has been a designer and fabricator of ceramic composite armor components since 1970 for a wide range of products from helicopter seats, aircraft armors, body armors and ceramic composite appliques for a range of vehicles. Figure 17 shows some of Simula's ceramic components. On the left is an AH64 helicopter seat that is fabricated from hot-pressed Cercom boron carbide on kevlar backing; the middle picture shows the Interceptor body armor vest with hot pressed ceramic tile inserts; and the photo on the right shows one-piece sintered silicon carbide plates made by M-Cubed of Monroe, CT which also can be used in the Interceptor vest.

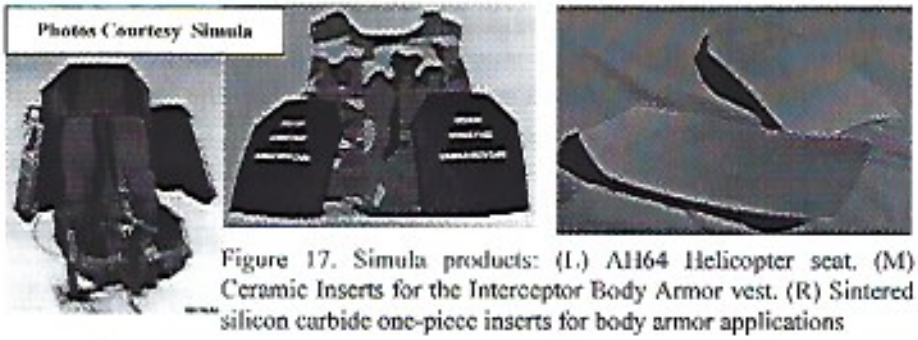


Figure 17. Simula products: (L) AH64 Helicopter seat, (M) Ceramic Inserts for the Interceptor Body Armor vest, (R) Sintered silicon carbide one-piece inserts for body armor applications

5.10 United Defense Limited Partnership

The Ground Systems Division of United Defense Limited Partnership (UDLP), headquartered in York, PA is one of the largest ground vehicle fabricator's in the U.S. The use of ceramic composite materials and structures has been in development for many years and UDLP has progressed through three generations of systems. The first generation development was the Composite Infantry Combat Vehicle technology demonstrator (Figure 18)

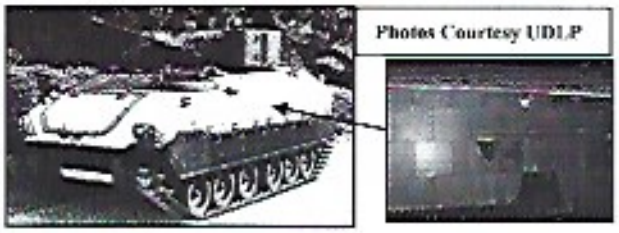
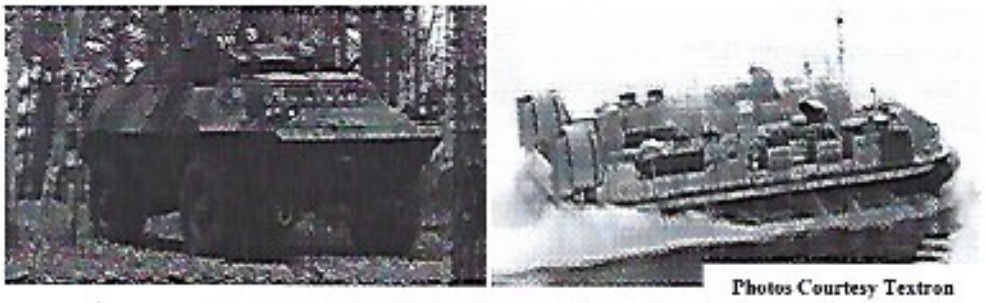


Figure 18. 1st Generation CIFV with TiB_2 tiles

based on a MEXAS™ license from IBD. Textron is currently working on a new composite armor design. The ASV offers front, rear and side protection from 0.50-caliber armor-piercing ammunition. The LCAC is a high-speed, over-the-beach fully amphibious, landing craft capable of carrying a 60-75 ton payload. Critical areas of the vehicle including the turbine housings are also protected with a Simula-developed, aluminum oxide composite.



Photos Courtesy Textron

Figure 13. The Textron ASV and LCAC vehicles both mount composite armors

5.8 General Dynamics Land Systems

General Dynamics Land Systems Division (GDLS), Sterling Heights, MI has licensed and acquired an advanced, lightweight armor technology, named SURMAX™ Armor. This armor technology is used on the sides and rear of the hull and the sides of the turret of the U.S. Marine Corps' Advanced Amphibious Assault Vehicle (AAAV) to protect the vehicle from 14.5-mm AP threats and artillery fragments (Figure 14).

SURMAX™ consists of a ceramic composite front panel attached to an armor backing. The backing can be a composite material (such as Kevlar or S-glass) or the structure of a vehicle (such as aluminum, steel, or titanium). The combination of the front panel and the backing are used to stop the penetrator and the application of SURMAX™ on the spaceframe structure of the AAAV is shown in Figure 14. SURMAX™ is also used on the U.S. Army's wheeled Armored Ground Mobility System (AGMS) and the flexible panels can be fit to curved surfaces such as wheel wells (Figure 15).



Photos Courtesy General Dynamics Land Systems

Figure 14. Marine Corp AAAV and SURMAX™ being mounted on AAAV spaceframe



Photos Courtesy General Dynamics Land Systems

Figure 15. SURMAX™ on AGMS with curved panels in wheel wells

which replaced most of the aluminum structure of the M2 Bradley Fighting Vehicle with a S-2 glass reinforced composite. This allowed the demonstration of bonding of titanium diboride tiles to the hull sides for 14.5-mm protection. Tile spacing and cutouts are visible.

The 2nd generation UDLP ceramic composite armors can be seen in the well-designed ballistic protection of the M8 Armored Gun System (Figure 19). The M8 is fitted with bolt-on appliques and boxes that can provide different levels of protection from KE penetrators to hand-held shaped charge warheads. The ceramic composite shows multiple impacts of 7.62-mm AP projectiles on the test panel.

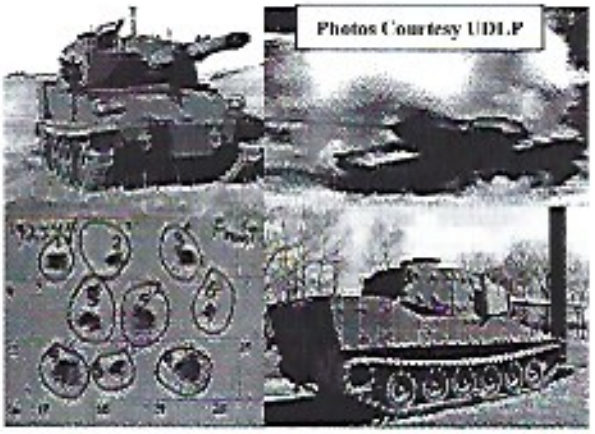


Figure 19. M8 passive/shaped charge armors being tested

The 3rd generation UDLP armor is seen in the Composite Armored Vehicle (CAV) technology demonstrator (Figure 20). The CAV incorporates full spectrum protection into the vehicle design, including 7.62-mm hull protection as well as enhanced 30-mm protection to the crew station. The multi-hit performance of the hex tiles used in the hull design as well as the excellent multi-hit protection of the silicon carbide/titanium crew station armor against 30-mm threats is shown.

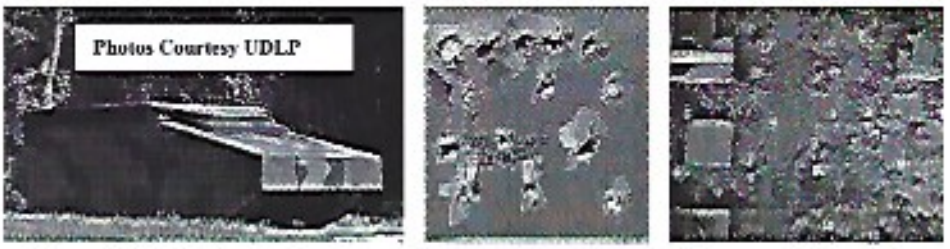


Figure 20. CAV Technology demonstrator and hull and crew station protection tests

6. CONCLUSIONS

This paper has presented an abbreviated overview and discussion of the ballistic requirements, ceramic design factors and chronology of significant U.S. developments over the last 30 years. The applications of ceramics for armor are growing rapidly as the need for lighter and more agile combat vehicles increases. Ceramic armor technology offers the best potential for meeting future protection requirements.

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