“High Performance Glass Fibers”

David Hartman

10 November 2008

ABMACO International Conference

OCV™ Reinforcements

DELIVERING SOLUTIONS | TRANSFORMING MARKETS | ENHANCING LIVES

OCV Reinforcements
70 Year History of Leading Innovation

- E glass in 1939
- C glass in 1943
- W1 and W2 in 1965
- S glass in 1968
- R glass in 1968
- AR glass in 1974
- ECR glass in 1980
- High alkali E glass in 1984
- Advantex glass in 1997
- H glass in 2004
- HPG glass in 2007

Glass and Melting Technology Innovation

- **1939: OCV invented E-glass**
  - Boron added to glass for electrical properties
- **1968: OCV developed S-2 Glass®**
  - High Performance Glass (high melting power needed)
  - Small capacity furnaces due to limits in melting technologies
- **1980: OCV developed ECR Glass®**
  - Acid Corrosion resistant glass.
- **1997: OCV developed Advantex® Glass and Technology**
  - Boron free E-glass (higher melting power than traditional E-Glass)
  - ECR-glass (Superior corrosion resistance to traditional E-glass)
  - Breakthrough in melting technology for large capacity furnaces
- **2006: OCV developed High Performance Glass Technology**
  - Combines High-Performance Glass and Melting Technology
  - Production of High-Performance Glass in large capacity furnaces

High Performance Glass

- **Breakthrough in advanced Glass Melting Technology**
  - Up to 40% increased strength
  - Up to 20% increased modulus
  - Up to 30% lower coefficient of linear thermal expansion
  - Up to 10x better fatigue properties
  - Superior corrosion resistance
  - Higher temperature resistance
- **With Environmental Stewardship**
  - **Reduced Emissions during Glass Production**
    - Less Particulate - No Boron
    - Less CO_2, NOx, HF
    - No Scrubbers => Eliminating Secondary Waste Stream
  - **Less Energy consumption**
    - Advanced Glass Manufacturing Techniques
    - Batch Formulation
  - **Longer Life for Composite Structure**

A demonstration of industry leadership

High Performance Reinforcements Product Line

WindStrand™ Reinforcements
FliteStrand™ Reinforcements
ShieldStrand™ Reinforcements
XStrand™ Reinforcements

Available as single end rovings or fabrics.

Fiber glass filament

Roving

Fabric

Final Applications

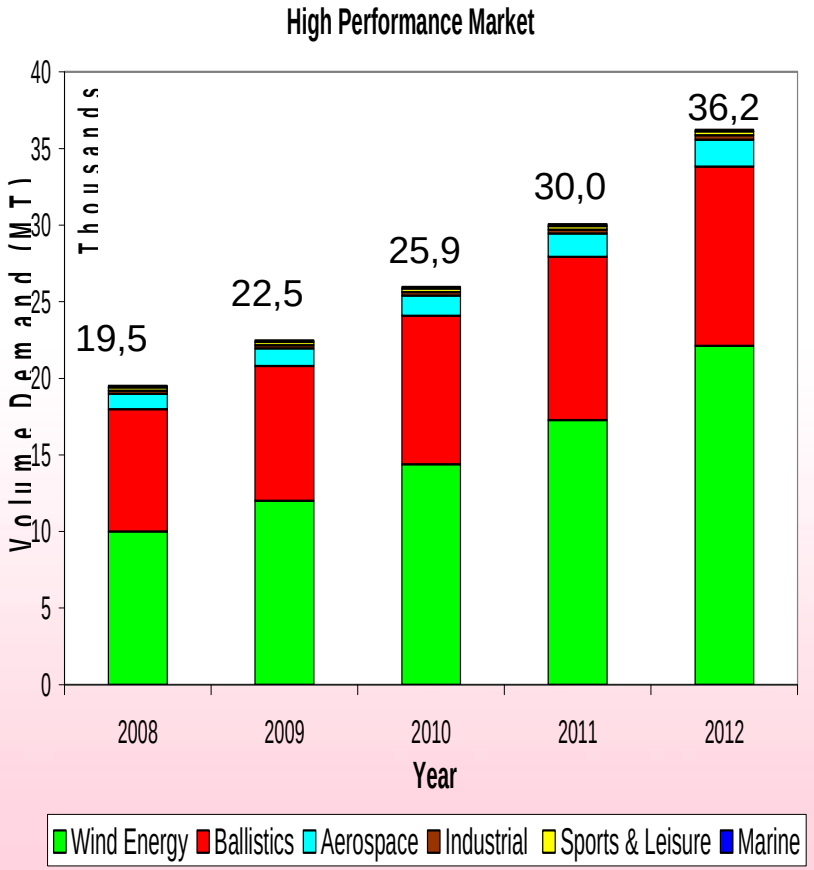
Product Offerings by Market

Owens Corning High Performance Reinforcement Platform

Markets	*Wind Energy*	*Ballistics*	*Aerospace*	*Industrial/Pressure Vessels*
Trademarks	**WindStrand™**	**ShieldStrand™**	**FliteStrand™**	**XStrand™**
Direct Rovings	**24µ - 2400 tex** **17µ - 2400 tex** **17µ - 1200 tex** **17µ - 600 tex** **12µ - 300 tex**	**12µ - 600 tex**	**12µ - 600 tex** **12µ - 300 tex**	**24µ - 2400 tex** **17µ - 2400 tex** **17µ - 1200 tex** **17µ - 600 tex** **12µ - 300 tex**
Sizings	EPOXY & MC	EPOXY & MC	EPOXY	EPOXY & MC

High Performance Market Trends

Segment	Estimated Growth %	Growth Drivers
Wind Energy	20	• Need for clean renewable energy (reduction of GHG) • Increase global energy consumption
Ballistics	10	• Increase in global warfare & terrorism • Light weight solutions to combat increasing threat
Industrial	10	• Clean efficient fuel source • Increasing safety standards
Aerospace	15	• Increase cost of fuel
Sports & Leisure	4	• Lower cost High Performance solutions
Marine	4	• High cost of fuel

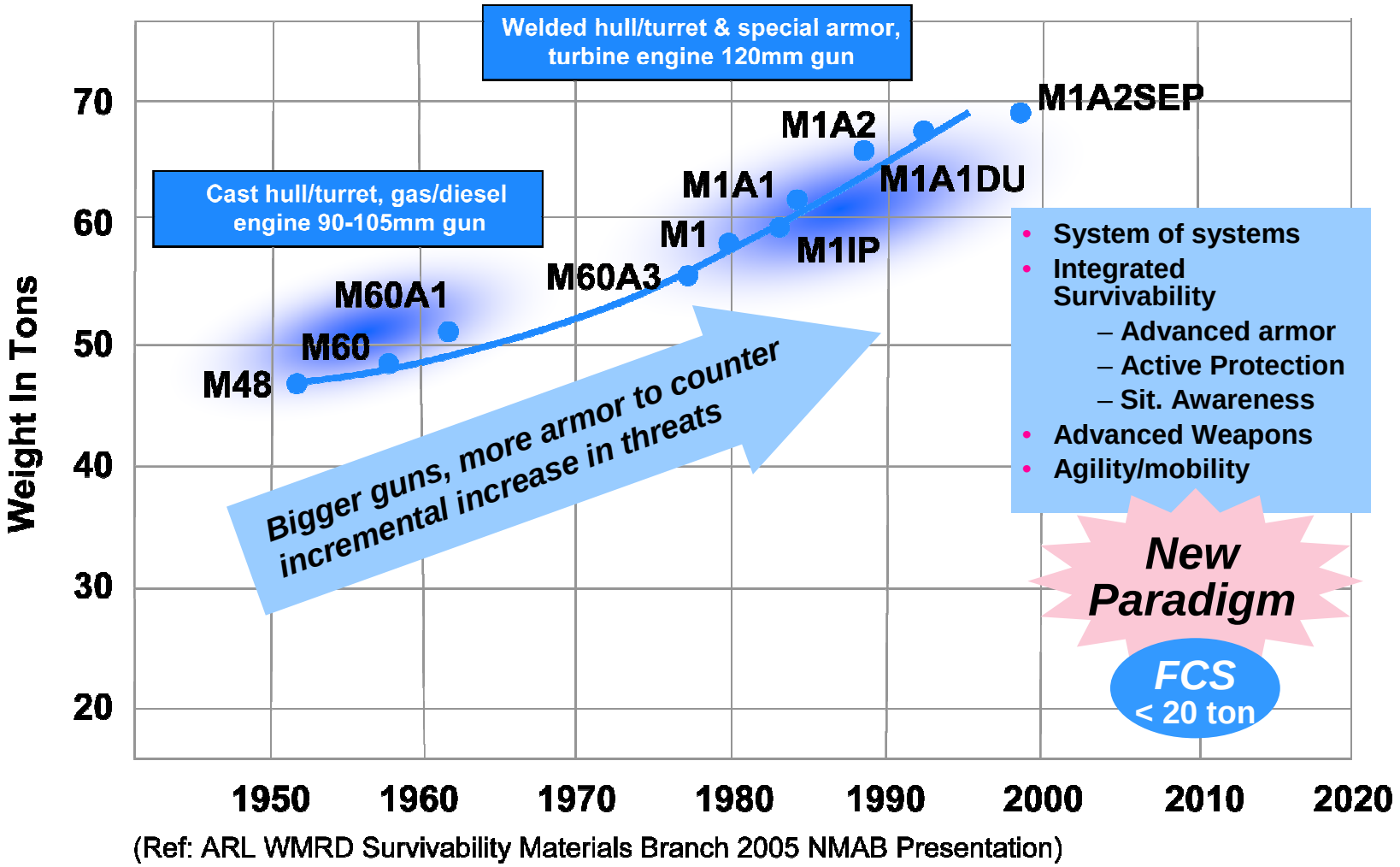


An emerging opportunity growing at 16% CAGR

Lightweight Composite Armor Market

Application Mobility and Ballistic Lethality Drives Performance

Rapid Deployment and High Mobility Drives Need for Paradigm Shift



(Ref: ARL WMRD Survivability Materials Branch 2005 NMAB Presentation)

Key Message to Meet Warfighter Needs

Save life and limb

Warfighter Mission

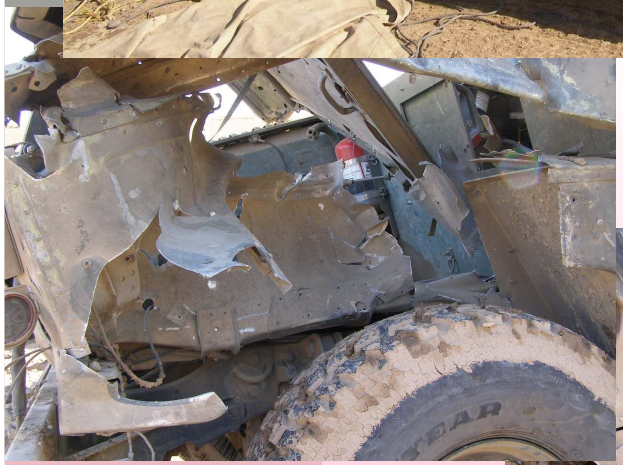
- **Protection against blast and fragmentation**
- **Performance improved with vehicle mobility**
- **Payload capacity increased**

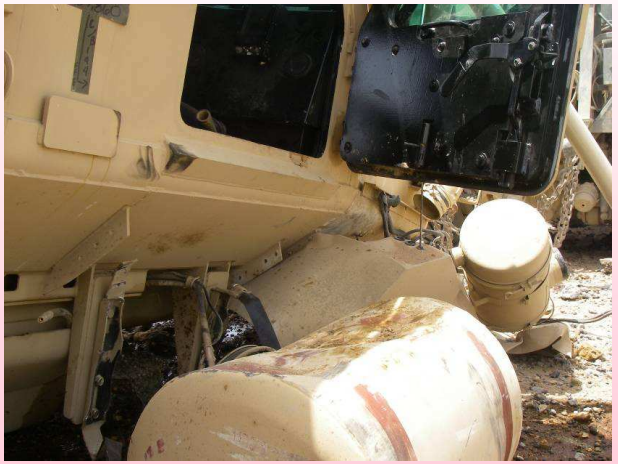
Supports Future Combat Systems

- **Lighter, faster, more fuel efficient vehicles**
- **Higher survivability at a reasonable price**

ShieldStrand™ Composite Armor Solution

Warfighter Needs Solution for Mine, IED and EFP - Blast and Fragmentation Protection





Ref: BAE Systems, AMGeneral

Benefits of ShieldStrand™ Armor Solutions

Tangibles - Mitigates Behind Armor Debris from Fragmentation and Overmatch Threats of IED, EFP

- Stronger
- Lighter
- Thinner
- Durable
- Affordable
- Consistent Supply Chain
- Phenolic Fire Resistance
- Ballistic Performance to Specifications for Composite Armor Systems MIL-PRF-64154
- Qualified for Spall Liner, Frag 5, Frag 6 and EFP

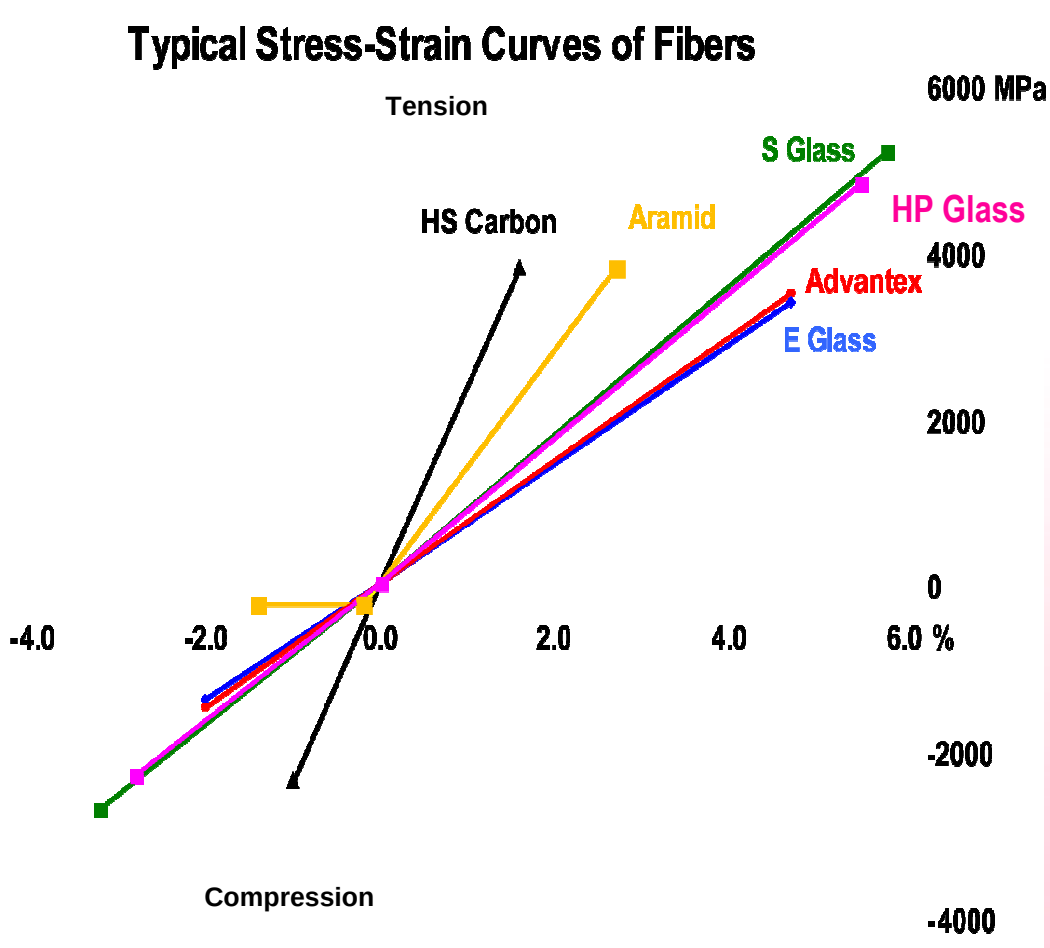
Benefits of ShieldStrand™ Armor Solutions

Intangibles – Heritage of Proven Spall Liner Field Performance and Prototype Structural Armor Hull Performance for Aluminum and Steel Substitution

- **Depot / Field Installation Capable**
- **Battle Damage and Repair Field Maintenance Capable**
- **Flat or Curved Plate or Complex Shape Demonstrated**
- **Installs with Fastener Systems typical to Metals**
- **Surface ready for CARC or adhesive for Metal and/or Ceramic Bonding / Joining**
- **No Corrosion or galvanic corrosion**
- **Good Durability to Vehicle Environment**
- **Complies with FMVSS 302 Flammability**

ShieldStrand™ Higher Strength Fiber

Introduced in 2007 HP Glass ShieldStrand™ Improves Composite Armor Performance and Affordability



Improvement over E Glass

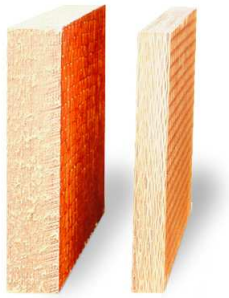
- Up to 40% higher strength
- Up to 20% higher modulus
- Better impact energy
- Better fatigue properties
- Superior corrosion resistance
- Higher temperature resistance
- Up to 30% better CTE

Improvement over other high performance fibers

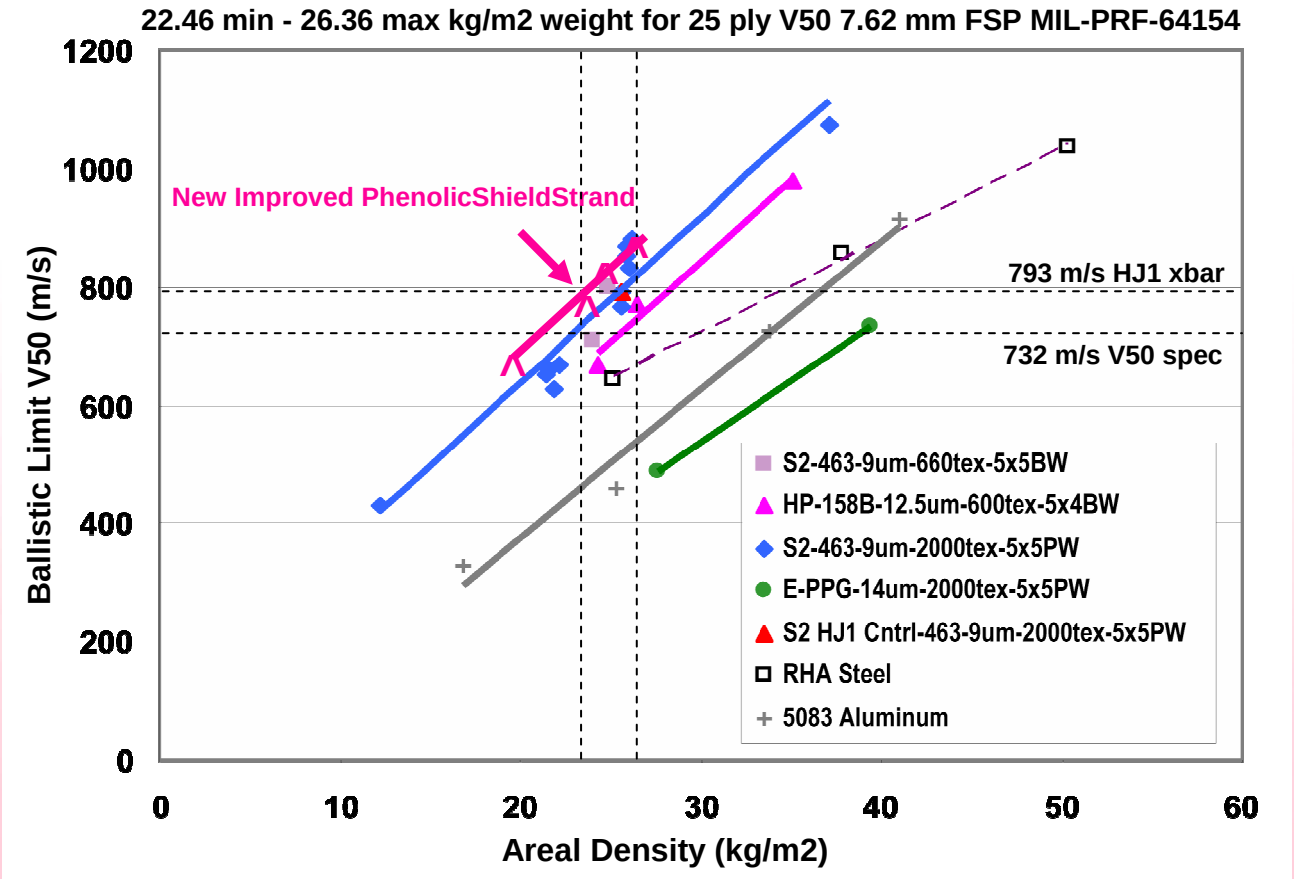
- Affordable
- Availability, higher volume

Approved to MIL-PRF-64154 for use in Lightweight Composite Armor

Similar Weight and Thinner than K29 Aramid Spall Liner->

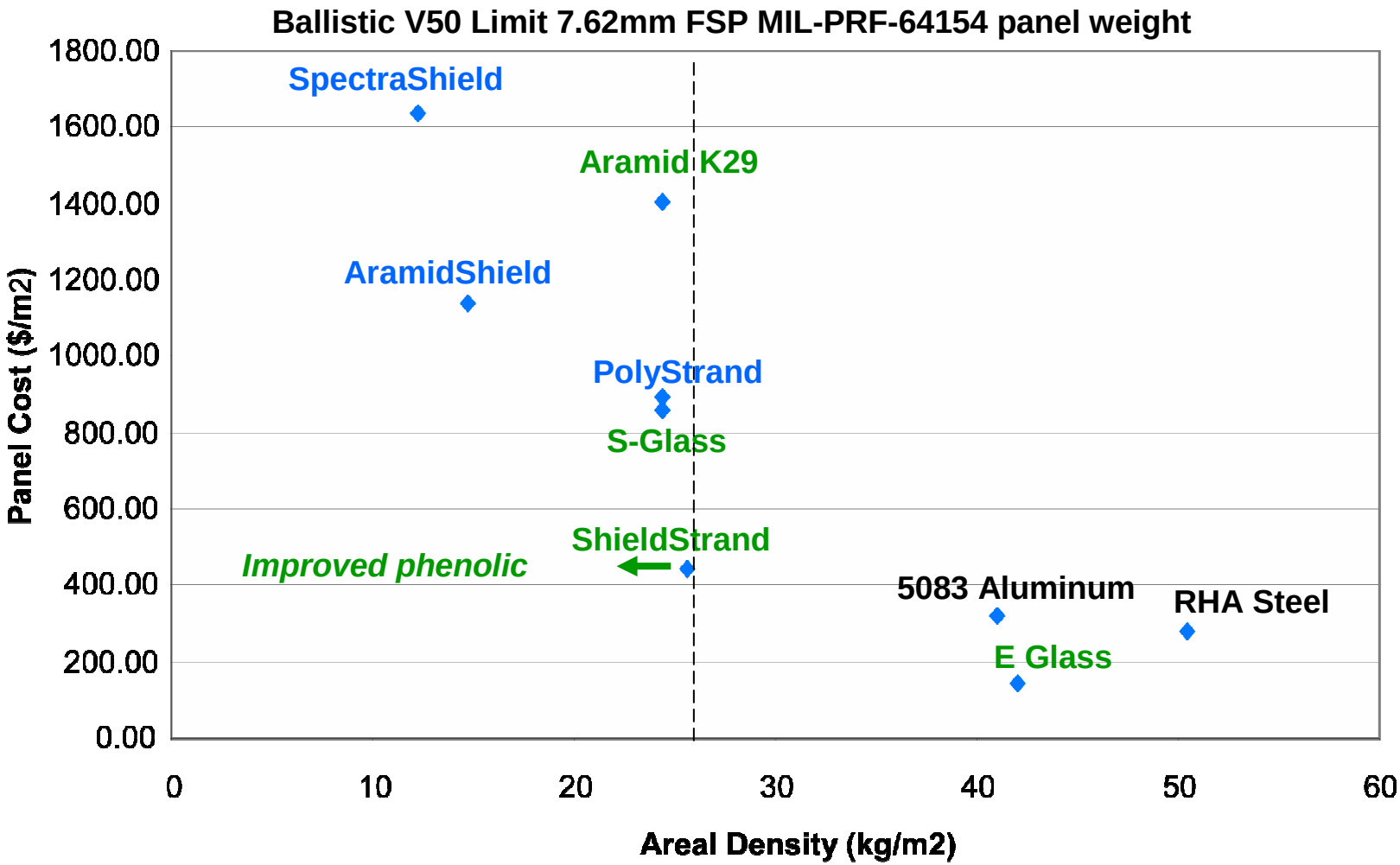


ShieldStrand™ Armor Solutions spall liner similar in weight and 30% thinner than K29 aramid

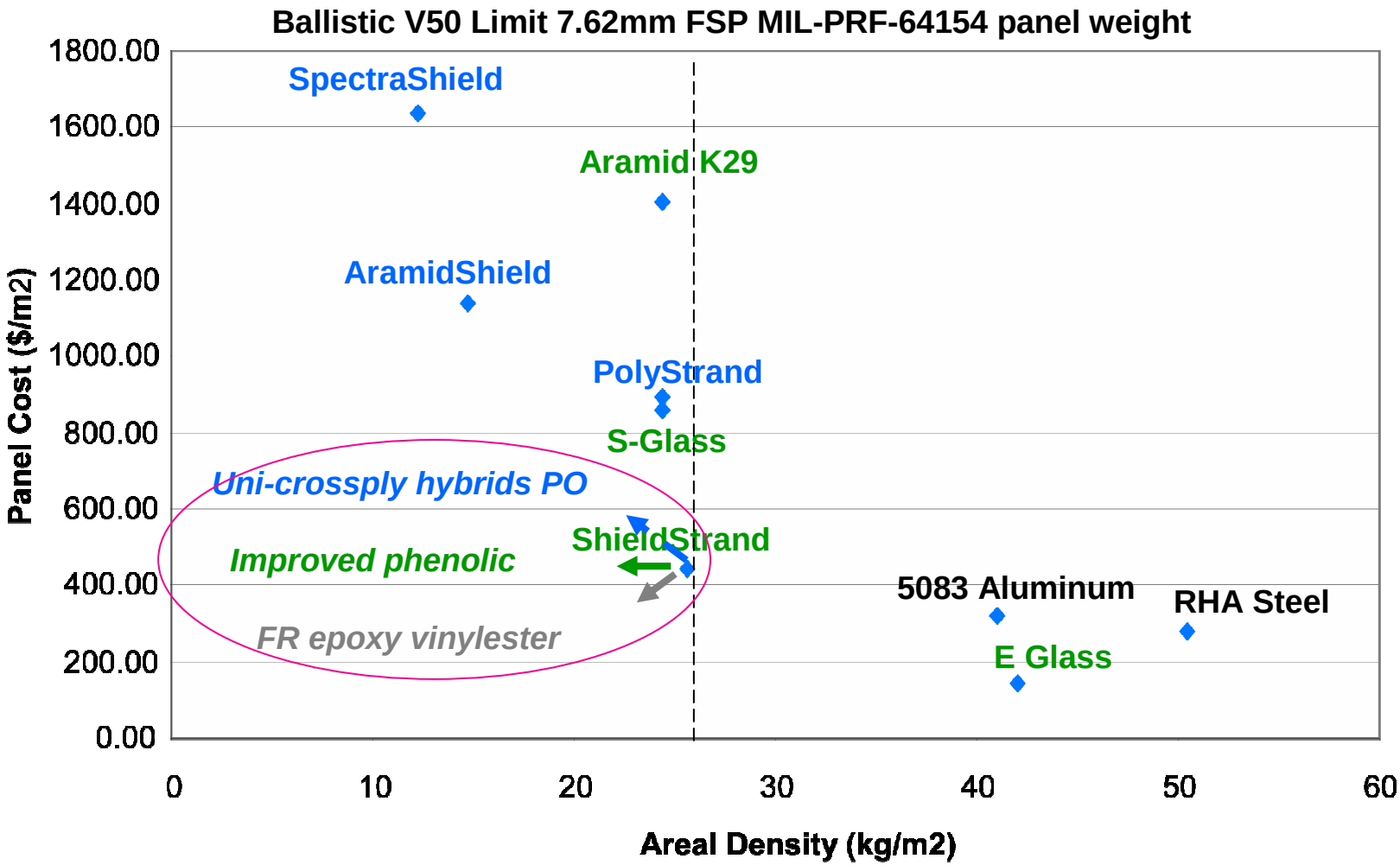


Ref: UDRI, ARL and HP White testing

ShieldStrand™ Armor Solutions Lighter and Affordable



ShieldStrand™ Armor Solutions Lighter and Affordable



Cost Substitution Comparison
Spall Liner Lighter Weight Basis

- **ShieldStrand™ Armor Solutions Cost Performance**
  - Similar in cost to Aluminum and Steel with up to 30% reduced weight potential in typical installation kit
  - Up to 50% reduced cost for S-Glass or Aramid substitution
  - Substitution for E glass depends on value of weight savings
- **Spall Liner Cost Performance**
  - E glass, steel and aluminum do not meet current weight criteria
  - Significant cost savings to S-Glass, Aramid and HMPE which meet weight criteria, overall savings depends on value of weight savings to mission payload.

ShieldStrand™ Armor Solutions Mitigate Behind Armor Effects of Fragmentation

Overmatch Fragment Simulation Behind Armor Debris

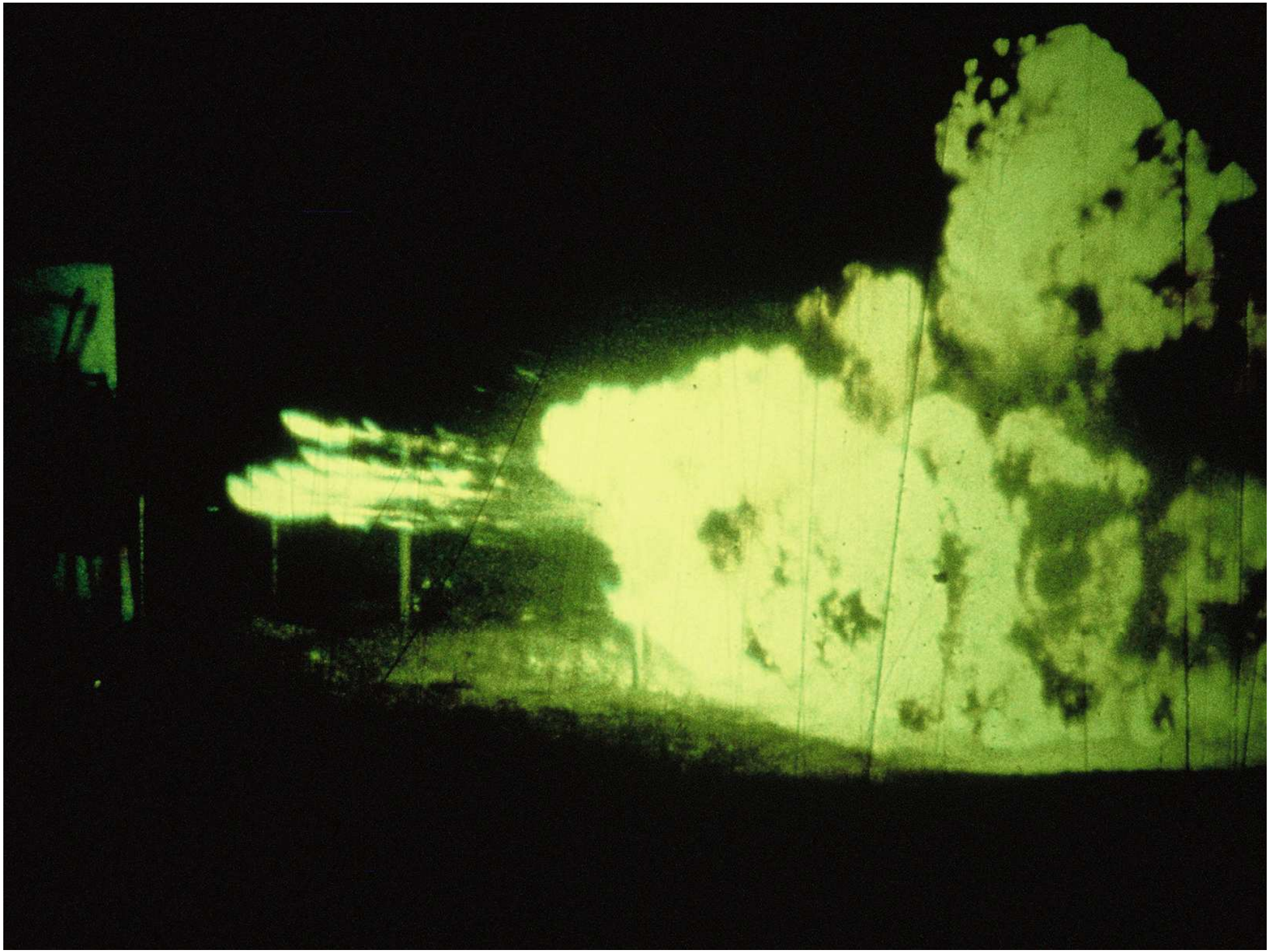
High Hard Steel

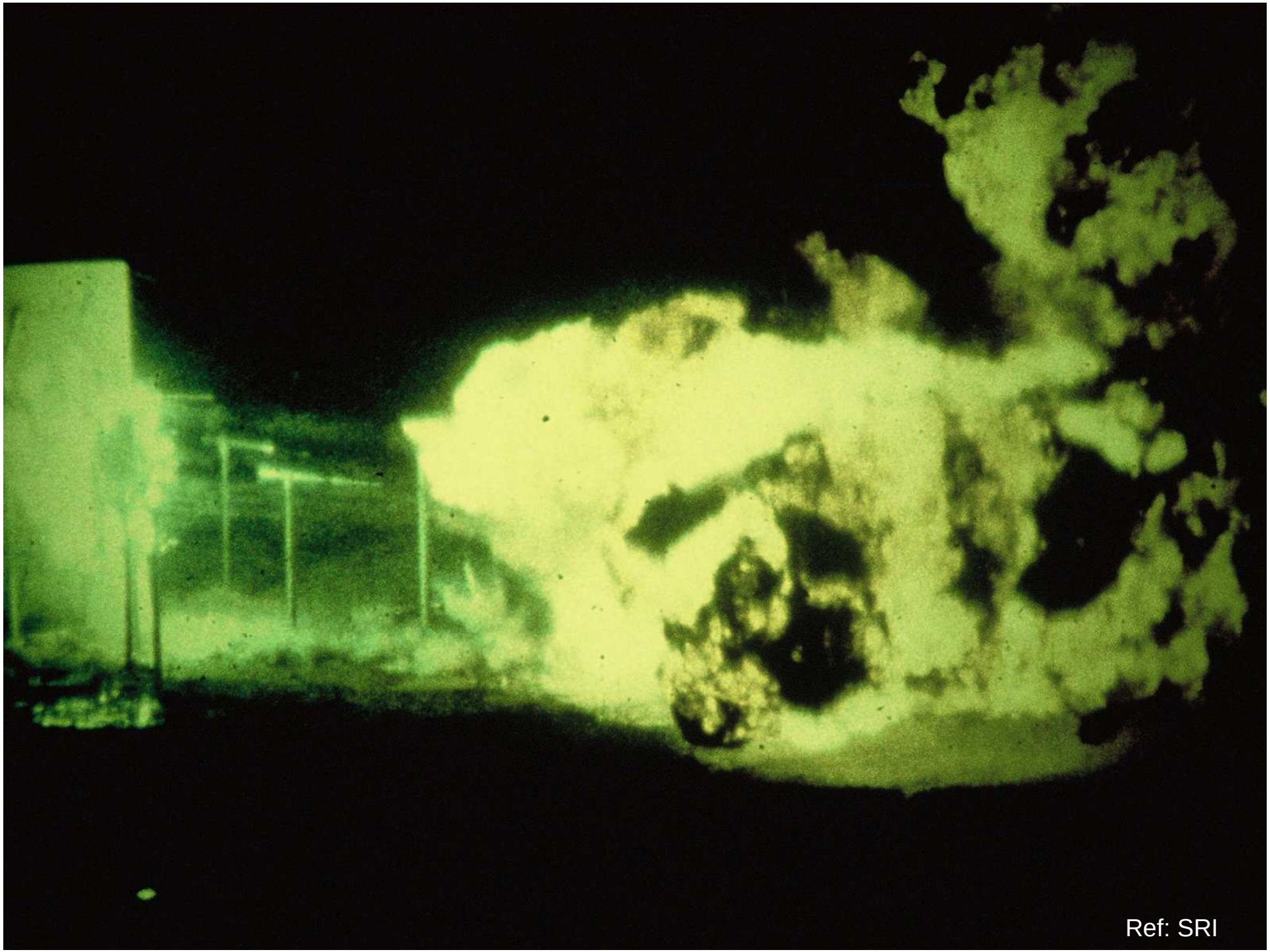
vs

ShieldStrand™ Armor Solutions

Source: H P White

ShieldStrand™ Armor Solutions Mitigate Behind Armor Effects of Fragmentation




Ref: SRI

Up Armored HMMWV (UAH) Requirements Increased to meet U.S. Congressional Order

Characteristics

- **360° protection against:**
  - Small Arms projectiles
  - Fragments from artillery
  - Anti-tank/ anti-personnel mines

Requirement

- **Current Total Requirement: 18,669 vehicles**

Status

- **As of 19 Apr 06, 12,800 UAH in the CENTCOM AOR**
- **Adding MRAP vehicles for higher protection**

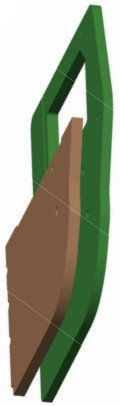
No Soldier leaves a base in an unarmored vehicle…

Ref: IDGA Ground Combat Vehicles 2006

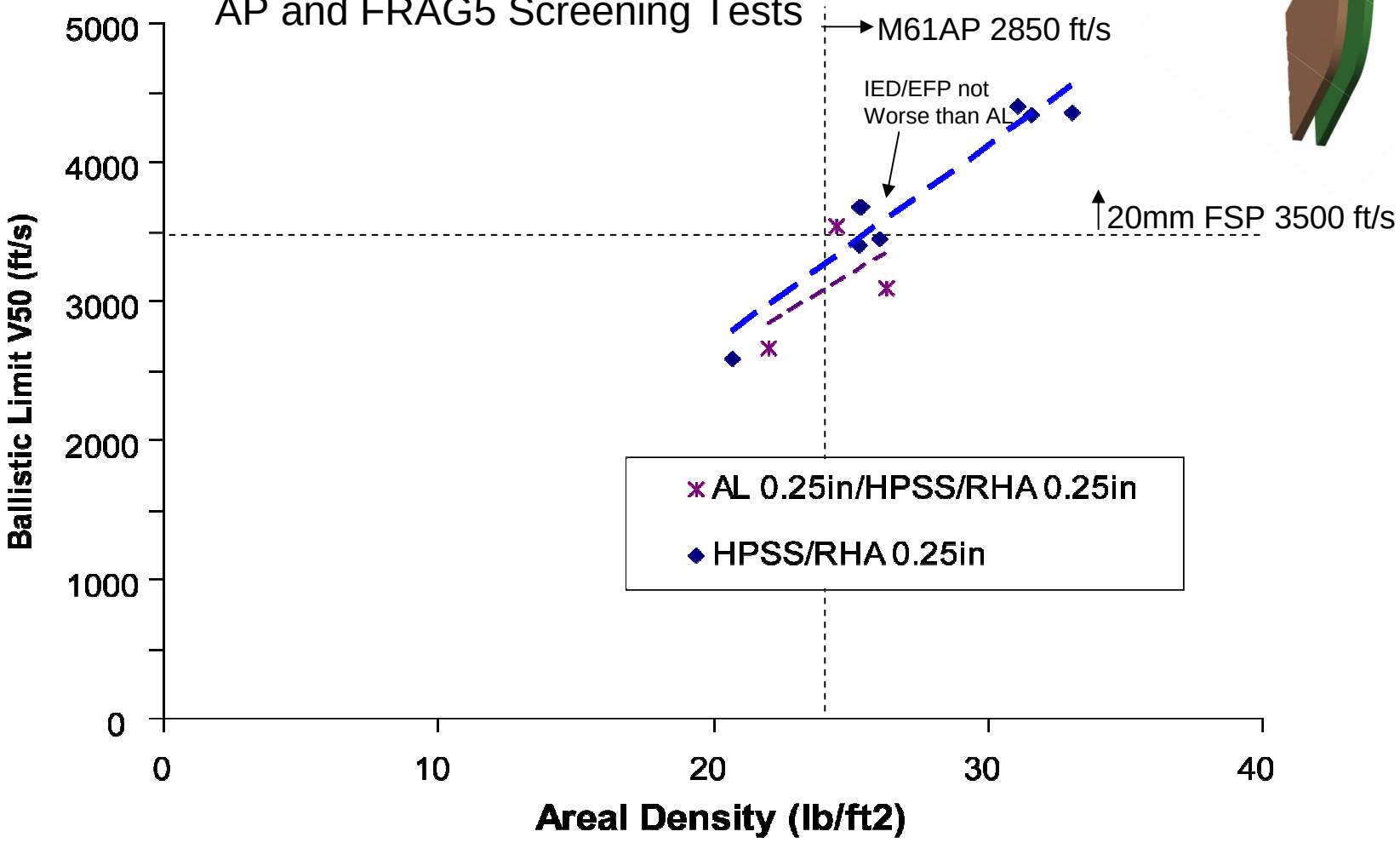
ShieldStrand™ Armor Solutions for HMMWV Fragmentation Kit Comparison with Aluminum

- **Drivers for substitution of Frag 5 kit**
  - Shortage of Aluminum
  - Cost of 5083 Aluminum
  - Spall reduction behind armor
  - Potential for reduced weight
  - Build more kits faster
  - Reduce dependency on foreign sources
- **Two options per ARL**
  - Substitute full thickness of aluminum (risk: edge effect, attachment)
  - Substitute for half thickness of aluminum (risk: behind armor effect)
- **Other options depending on overmatched threat**
  - Substitute full thickness aluminum and additional for Frag 6
  - Exceed FMVSS 302 fire requirements
- **Cost performance versus 5083 Aluminum**
  - Depends on weight saved after installation up to 20% savings

ShieldStrand™ Armor Exterior Modules Ballistic Multi-threat Performance



AP and FRAG5 Screening Tests



Areal Density Includes 10.5 lb/ft2 RHA Steel Door Skin

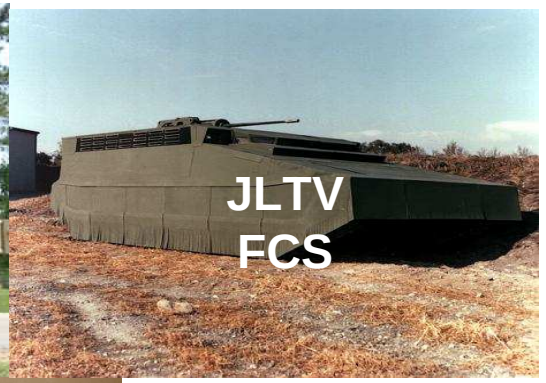
Ref: UDRI, AMG NTS, BAES testing

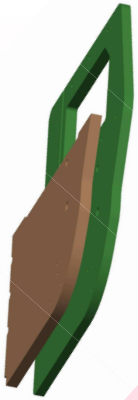
ShieldStrand™ Armor Solutions Weight Saving Benefits

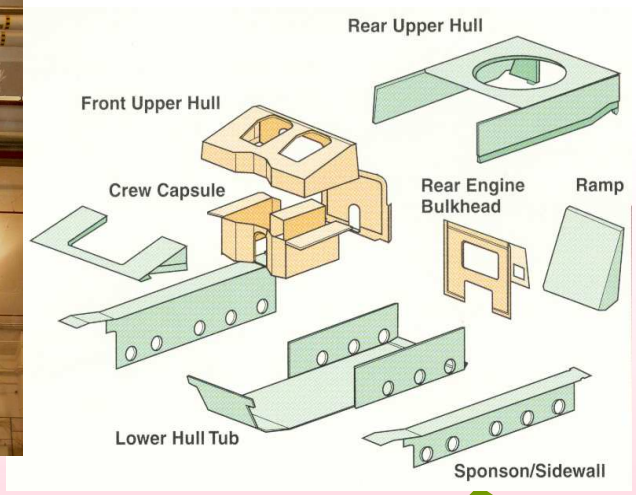
- **Up to 30% weight savings versus metals**
- **Up to 50% cost savings versus S-Glass and Aramid**
- **Weight and cost savings depend on the MRAP or HMMWV vehicle kit - M1114, M1152 or M1165**

Ref: AMG, Intl., IDGA Ground Combat Vehicles 2006

Evolution of Composite Armor from flat plate to complex shapes for integration with steel



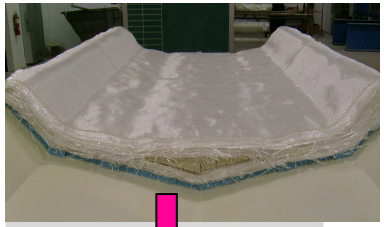


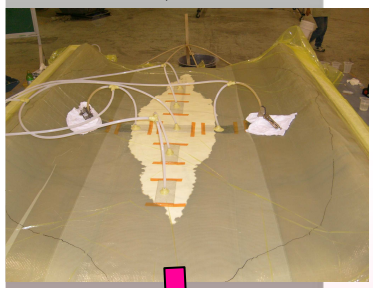


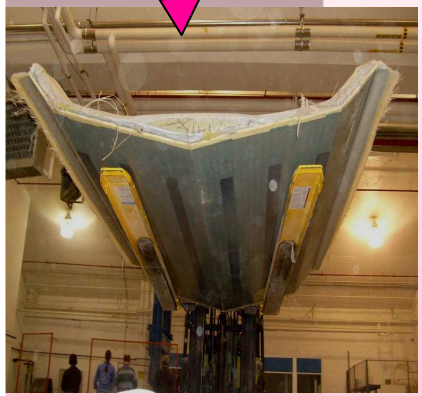
spall liners → exterior armor modules → v-hull → structural components

Compression Molded Phenolic ***Infusion Molded FR Epoxy Vinylester***

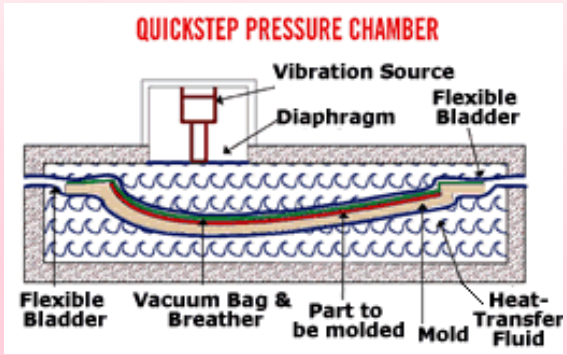
Evaluation of ShieldStrand™ Material and Process Parameters for Complex Shapes



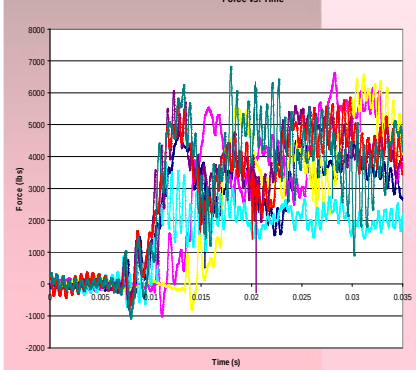




- Resin Infusion of large V-hull structure of ShieldStrand, TYCOR foam and metal inserts resulted in good structural, blast and fragmentation performance.
- Nano FR synergists allowed excellent vinylester resin infusion process resulting in good fire performance.
- QuickStep process consolidation of phenolic prepreg in complex shapes gave 90 - 95% of the ballistic performance of compression molded phenolic.
- QuickStep demonstrated capability to produce 4 inch thick complex parts with reasonable process time at the National Composites Center.

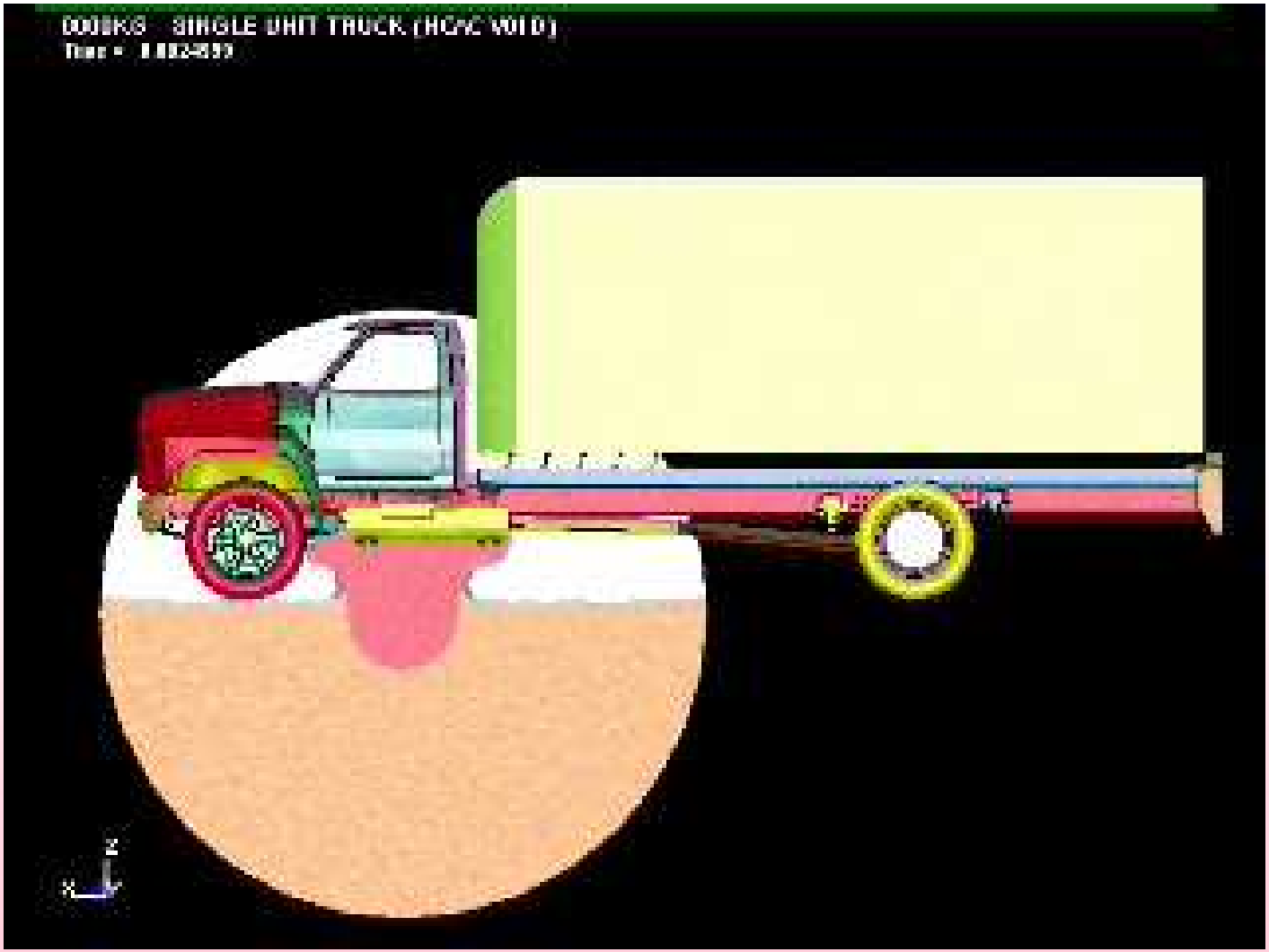


ShieldStrand™ Armor Solutions for Blast and Multi-hit Fragmentation Performance



- **Effective Blast Management – structurally good with minimal global deflection for up to 20lbs C4 or equivalent CB with 18 and 32 inch standoff.**
- **Local Deflection with Large Fragment > 94 percentile.**
- **FR Vinylester ShieldStrand V-hull Passed 155mm mortar buried flush with standoff at 32 inch… V-hull was then subjected to full scale diesel fuel fire test and Passed.**
- **Minimal Secondary Effects Behind Armor – V-hull vents Blast, Composite stops fragmentation, while structure absorbs Blast energy and dissipates shock.**
- **Blast Simulation Modeling at UDRI and OSU for Composite Structures with comparison to LS Dyna with Johnson Cook parameters.**
  - (Ref: SwRI, BAE, AMG, ARL/ATC pending reports, DAAL04-92-C-0014, DAAL04-86-C-0079 armor reports)

Blast Resistance Simulation with LS Dyna FEA Tools for Design and Integration in Vehicles



Ref: ARL, OSU, NCC, UBA

Up Armored Add-on Vehicle Armor Kits

OGH HMMWV Kit

Produced By:
Armor Holdings Inc.
BAE Systems

ARL HMMWV Kit

Produced By:
GSIE/ARL

Troop Carrier Kit

Produced By:
ArmorWorks

M1114 UAH
Gunners Protection Kit

Produced By:
Armor Holdings Inc.
BAE Systems

FMTV RACK Kit

Produced By:
ESSI Inc.
(Radian/SEI)

FMTV LSAC Kit

Produced By:
Stewart & Stevenson

Ref: IDGA Ground Combat Vehicles 2006

Add-on Armor Kits for Medium Weight Tactical Vehicle Platforms

M939 Kit

Produced By:
GSIE

HEMTT Kit

Produced By:
Armor Holdings Inc.
BAE Systems

PLS Kit

Produced By:
Armor Holdings, Inc.
BAE Systems

HET Kit

Produced By:
Armor Holdings Inc.
BAE Systems

M915A2/3/4 Kit

Produced By:
Armor Holdings Inc.
BAE Systems

M969 FTSS

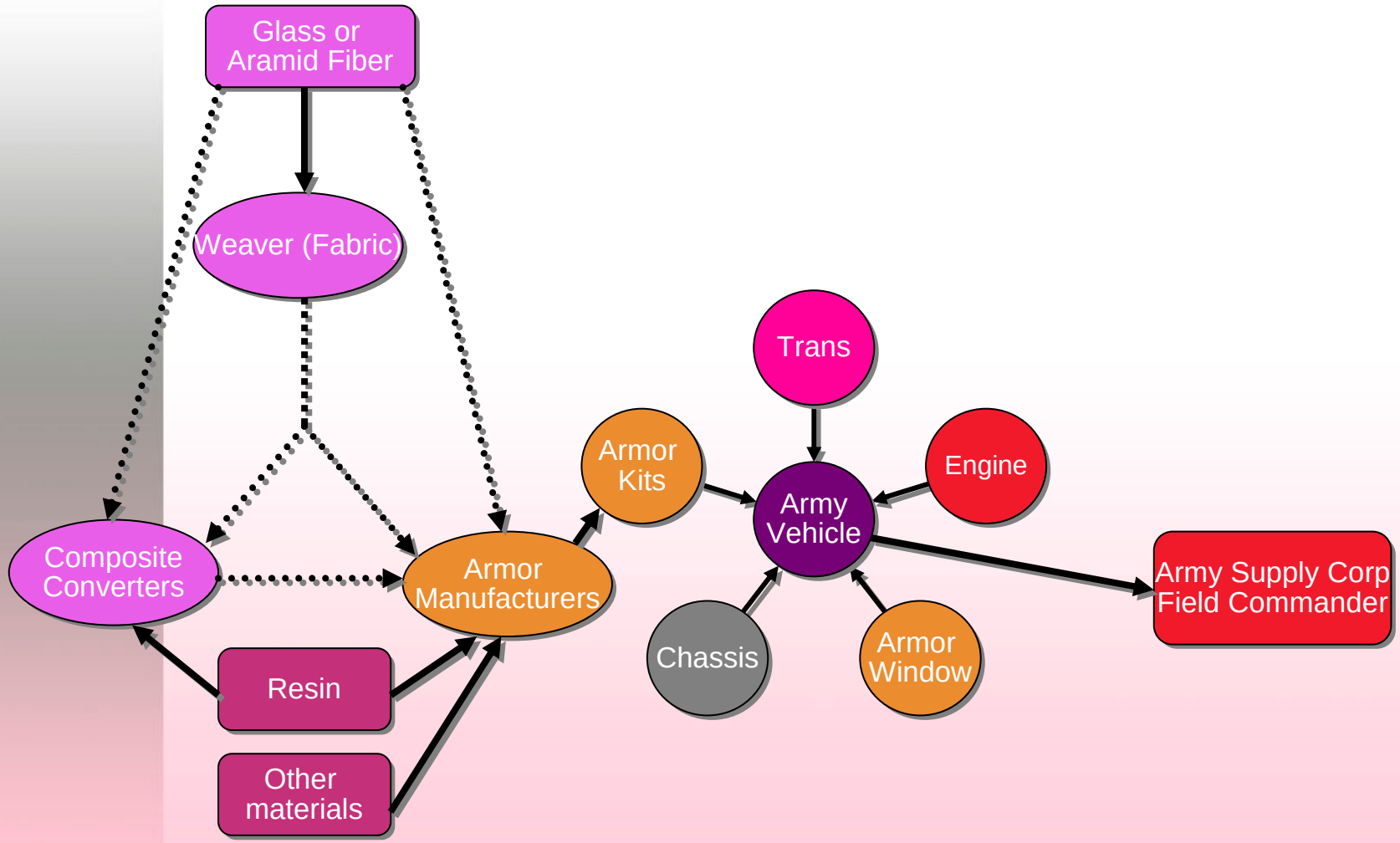
Produced By:
VSE Corp

ASV

Produced By:
Textron

Ref: IDGA Ground Combat Vehicles 2006

Vehicle Armor Proven Supply Chain



ShieldStrand™ Armor Solutions Summary

- **ShieldStrand™ Armor Solutions**

  Affordable Lightweight Performance
  - High strength, high modulus glass fiber available in large quantities
  - Comparable ballistic performance to S-Glass in HJ1 phenolic plates at about half the cost.
  - Substitution for S-Glass/K29 Aramid in spall liners – lower cost lightweight solution
  - Replace or combine with aluminum, steel and E-glass – where weight is critical and over match threat levels exist
- **Drivers for Substitution of Aluminum or Steel**
  - Shortage of metal
  - Recent cost increases
  - Spall reduction behind armor
  - Build more kits faster
  - Reduce dependency on foreign source
- **ShieldStrand™ Armor Validated Supply Chain Performance**
  - Ballistic performance data qualified in the existing supply chain
  - Fibers & fabrics are available to the existing supply chain for processing in low-cost pultrusion, continuous lamination or compression molding of flat plates and compression or infusion molding of complex shapes

Owens Corning Military Innovations

- **E-glass – First continuous filament glass reinforcement developed.**
- **Insulation for Warships (1939) – U.S. Navy Bureau of Ships specified OC insulation for new ships.**
- **Structural Aircraft Parts (1942) – OC partnered with U.S. A.A.F. to develop plastic laminates.**
- **Beta® yarn (1963) – OC develops fiber for aerospace applications and use in NASA spacesuits.**
- **S-Glass® (1959-63) – Developed by OC under contract with U.S. Navy.**
- **Piedmont Products, Inc. (1979) – OC manages reinforcements plant under government contract**
- **OC Armor (1989) – Product specified for NATO and US Military personnel carriers and first-aid trucks.**
- **ShieldStrand™ High Performance Reinforcements (2007)**