



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Ballistic Protection

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Mission

- Mature Armor Systems from Technical Readiness Level (TRL) 4 to TRL 6 to fulfill ground vehicle Program Management (PM) needs.

Base Armor

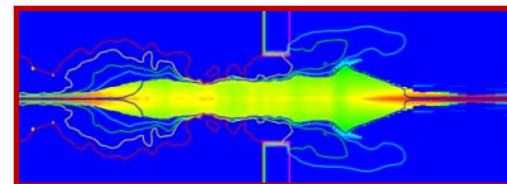
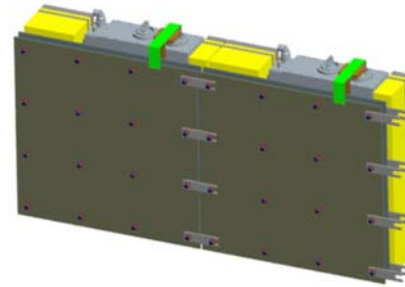
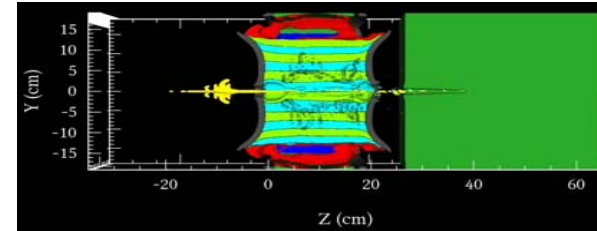
- Small Arms/Frag Opaque B-kits
- Medium Cal/Frag Opaque B-kits
- Transparent Armor

Appliqué Armor (C-kit)

- Passive Multi-Threat
- Reactive Multi-Threat
- Active Multi-Threat

Integration / Design Enablers

- Scalable, Modular & Common Armor System Integration Techniques
- Multifunctional Armors
- Modeling & Simulation
- Testing Capabilities



ARMOR INTEGRATION & MATURATION ↓	TRL	General Definition	Armor Package Definition	Industry Partnership
	4	Component validation in a lab environment	Armor meets ballistic performance (threat, number of shots, multi-hit shot spacing, velocity) at the <u>coupon level</u> .	Yes
	5 	Component validation in a relevant environment	Armor maintains ballistic performance at the <u>coupon level</u> after <u>exposure</u> to <u>relevant environments</u> or in packaged configurations.	Yes
	6 	Subsystem / system demonstration in a relevant environment	Armor maintains ballistic performance after <u>packaged/mounted</u> on a <u>vehicle-representative structure</u> and after <u>introducing relevant environments</u> and relevant threat engagements.	Yes

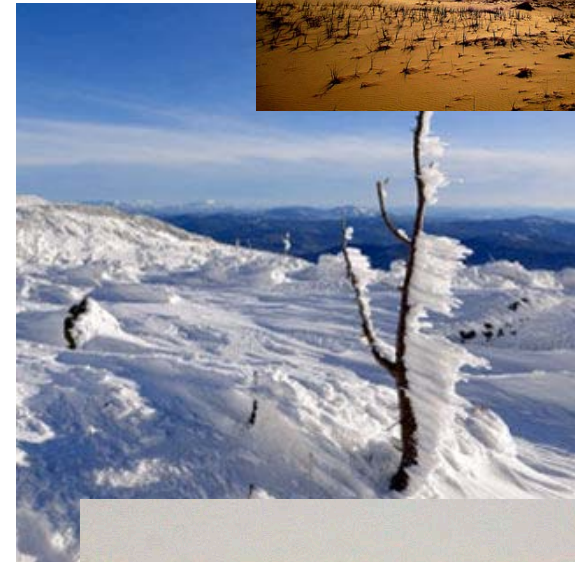
The following tests have been identified as potential tests that could be required for maturation of a new armor design. The tests required will be dependent on the materials and uniqueness of the armor design.

MIL-STD 810

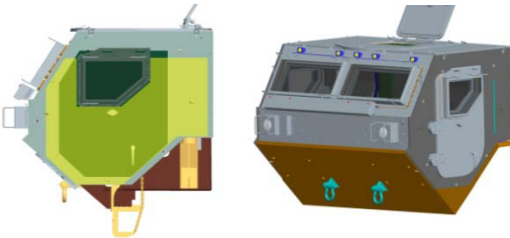
- Heat Loading
- Cold Loading
- Thermal Cycling
- Contamination by Fluids
- Solar Radiation
- Rain
- Humidity
- Salt Fog
- Sand & Dust
- Acidic Atmosphere
- Vibration
- Shock
- Fire, Smoke & Toxicity

ATPD 2352 (First Article)

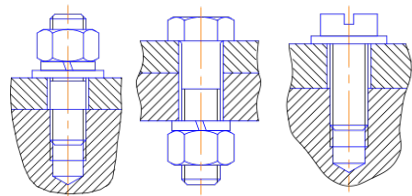
- Allowable Defects
- Transmittance
- Haze
- Optical
- Chemical
- De-icing
- Humidity
- Abrasion
- Sun Exposure
- Weathering
- Ballistic (@ ambient temp)
- Temp (Shock, Low & High)
- Rock Strike / Low Impact



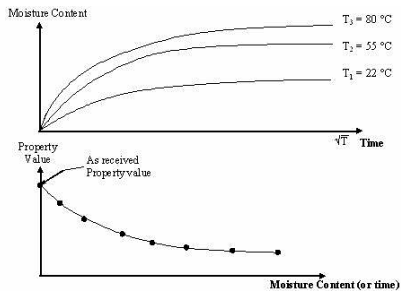
Modeling & Simulation
and Design
(TRL 5 & 6)



Reduce Ballistic Vulnerabilities



Integration Burden Mitigation /
Ballistic Performance Design

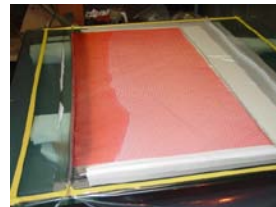


Environmental / Durability
Simulations

Fabrication (TRL 4, 5 & 6)



Ceramics



Composites



Metallic



State-of-the-Art
Combinations

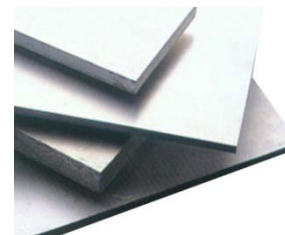
Coupon Level Ballistic
Testing / Validation
(TRL 4, 5 & 6)



Small and medium caliber
ballistics / frag testing



Transparent Armor Testing



Opaque Armor Testing

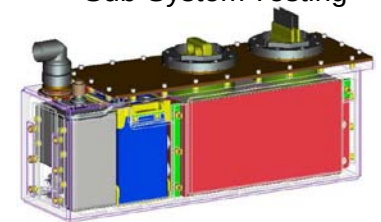
System / Sub-System
Integration and Testing
(TRL 6)



System Installation



Sub-System Testing



Integration of Enabling
Technologies

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Name	FY						Description
	11	12	13	14	15	16	
Advanced Combat Vehicle Armor Development (ACVAD)							Reduced cost, lighter weight, extended multi-threat 2nd generation B and C combat armor systems: • B kit - encapsulated ceramics • C kit - passive, reactive & electro-magnetic • Health monitoring
Armor Development							Research, development & testing of armor system maturation enablers: • Emerging technologies • System engineering process • Standards (design, integration, test) • Manufacturing capabilities • Test & evaluation of A & B armor systems
Transparent Armor (TA)							Research, development & testing of transparent armor: • Reduced interlayer de-bonding • Rock strike abatement • Lighter weight strike face & interlayer • ATPD 2352 revisions • First article & production quality control testing

Purpose:

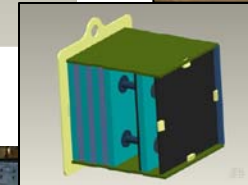
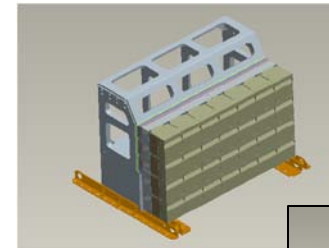
- Further mature and develop weight / space trades to reduce cost of the threshold CVAD armor for GCV
- Develop GCV objective threat armor system while meeting platform weight, space and cost goals
- Advance electro-magnetic armor systems maturity
- Develop smart armor with embedded, real-time health monitoring capability.

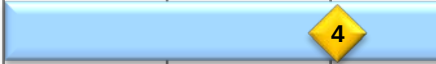
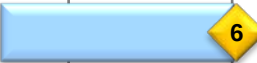
Requirements:

- Reduce CVAD cost, weight and/or space performance parameters while maintaining threshold threat protection.
- Transition objective threat TRL 6 armor systems to GCV in FY16 for block upgrade

Products:

- Next generation combat armor systems demonstrated ballistic performance after packaged / mounted on a vehicle or representative structure and after introducing relevant environments
- Improved modeling & simulation tools for advanced threats and materials
- Efficient manufacturing processes for armor designs
- Embedded ultrasonic and optoelectronic sensors for health monitoring of ceramic and transparent armors



Milestone / Activity	FY12	FY13	FY14	FY15	FY16
Armor technology trade studies / continued threshold armor improvements and <u>maturation activities</u> (weight, space claim, performance vs cost). Determine armor <u>sensor options</u> per recipe and recognize defect identification.					
<u>Early performance evaluations</u> on down selected armor samples (risk mitigation test data). Evaluate results for thermal exposure, automotive inputs and ballistic multi hit shots. <u>Validate sensor integration</u> performance post vibration and environmental testing. Continue armor maturation activities and plan integration efforts.					
Armor development effort and <u>TRL 4 recipe transitions</u> . Level 1 & 2 B-kits and Level 0, 1 & 2 C-kits.					
Finalize <u>risk mitigation</u> evaluations on C-kit designs. Mature armor and <u>conduct TRL 5 testing</u> of armor designs (environmental & structural), conduct effect of defects study to determine how manufacturing defects change armor performance.					
<u>TRL 6 armor panel design</u> , attachments, integration, and system level test. Includes vibration, environmental & combined effects.					

Armor TRL Requirements and Responsible Organization

		
<u>TRL 4</u> Coupon Level Performance	<u>TRL 5</u> Coupon Level Performance after Relevant Environment	<u>TRL 6</u> Armor System Performance after Relevant Environment

- ACVAD TRL 6 armor deliverables to GCV (with non integrated weight targets)
- TARDEC's armors will include metallic, composites, glass, ceramics, 3D weave, MMC and metallic encapsulated ceramics. C-kit armor defeat technologies include passive, reactive and electro-magnetic

Armor Description	Vehicle Area	CVAD Weight	ACVAD Weight	Total Cost
B-kit Level 1 Threshold	Side	xx psf	0% psf	-% Chg
B-kit Level 1 Objective	Side	N/A	0% psf	-% Chg
B-kit Level 2 Objective	Side	N/A	0% psf	-% Chg
C-kit Level 0 Passive	Side	xx psf	-21% psf	-% Chg
C-kit Level 1 Passive	Side	xx psf	-21% psf	-% Chg
C-kit Level 1 Active	Side	xx psf	-29% psf	-% Chg
C-kit Level 2 Objective	Side	N/A	0% psf	-% Chg

ACVAD POC: Douglas Bertoia

Purpose:

Mature, integrate and demonstrate high energy / high power compact power control / distribution devices for defense applications

Electro-Magnetic Armor (EMA)

- Integrate and test the Pulse Power Unit with hybrid armor modules for low risk EMA
 - Testing to include durability, environmental and limited live fire testing
- Develop, integrate and test Power Brick based EMA with focus on operation, condition monitoring, and safety

High Energy Laser Tech Demo (HEL-TD)

- Develop, test and deliver Next Generation Laser Power Supply (reduced size, weight, increased power per kg)

Customers:

- Electro-Magnetic Armor: PEO-GCS, GCV Increment 2
- High Energy Laser Programmable Pulse Power Supply (PPPS) : Space and Missile Defense Center (SMDC).

Products:

Electro-Magnetic Armor (EMA)

- Silicon carbide based devices and components for EMA
- High Energy Density Capacitors for EMA
- 2nd Gen EMA Control Interface

High Energy Laser Tech Demo (HEL-TD) coordinated with SMDC

- Next Gen Laser Power Supply High Energy Laser Tech Demo
- New Advanced Pulse Forming Network (APFN) cards
 - 40% smaller than previous generation
 - Increase run time with less thermal management burden

Payoff:

- Enable Electro-Magnetic Armors
- Enable future High Energy Laser (HEL) Demonstrations

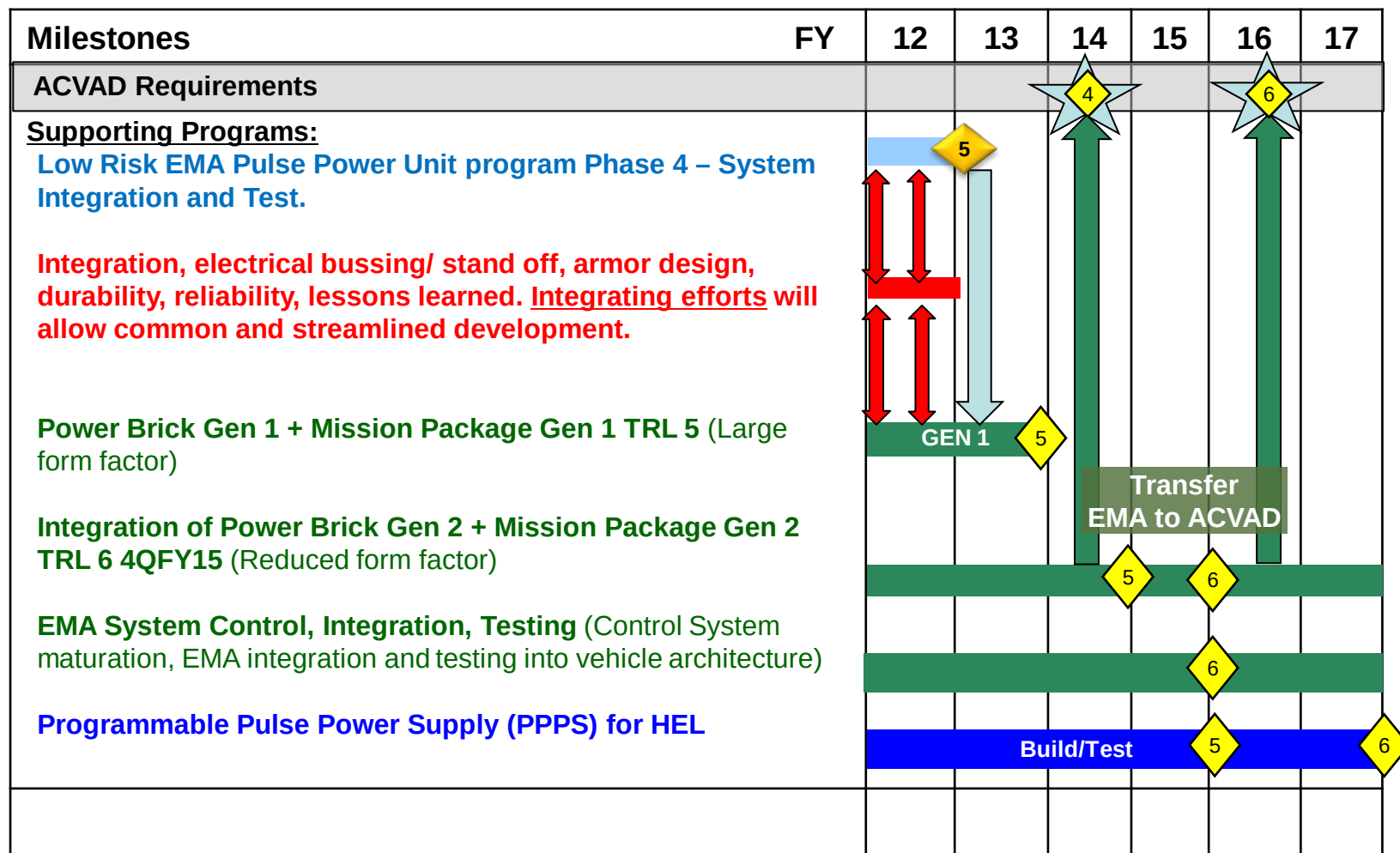
Electro-Magnetic Armor with Power Brick

- Component & module development
- Integrated modules developed to fit in drift space
- Control system maturation



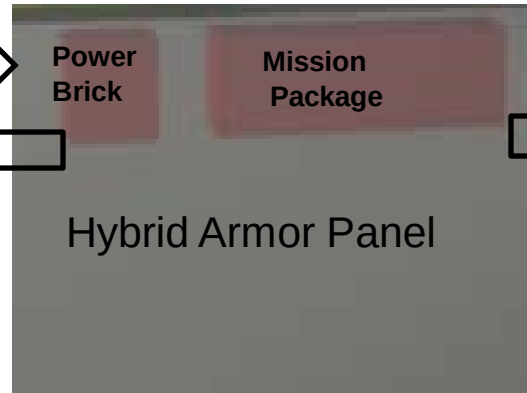
Laser Power Supply



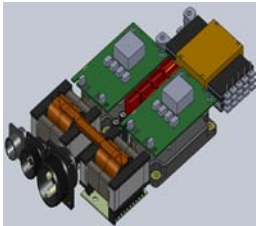




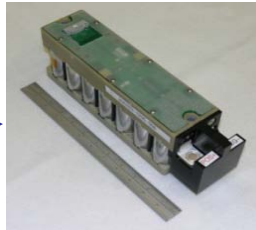
- Multi-hit system without recharging
- Provides support to meet emerging survivability threats
- Enables multi-threat armor systems



Power Brick



DC to DC Charger
28V to 600V
Assembly starting
in Summer 2011



Battery
(Prototype)

Mission Package



Pulse Charger
600v to 10kV
(Initial Design)



Capacitors
High Energy Density
(1.3J/cc)

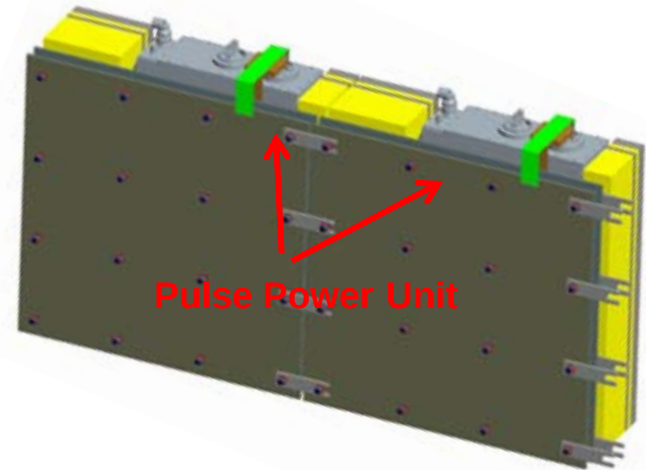


Solid State Switches
Silicon, 2cm², 12kA
SiC, .73cm², 5kA

EMA/Pulse Power POC: Joe White

Milestone Schedule	FY10	FY11	FY12
Phase 1 – Armor Module Recipe Validation		4	
Phase 2 – Component Integration and Test			
TARDEC design and build 1 st gen LR EMA			
Contractor design and develop Pulse Power System			
Test Series I – Ballistic (Single Modules)			
Phase 3 – Subsystem Integration and Test			
TARDEC design and build 2 nd gen LR EMA			
Test Series II – Environmental/Durability/Ballistic			
Phase 4 – System Integration and Test			
Test Series III –Ballistic (Multiple Modules)			

TARDEC Armor System Modules



Project Goals

Weight	xx psf	xx psf (integrated)	-10% psf (integrated w/ PPU)
TRL	4	4+	5

EMA/Pulse Power POC: Joe White

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Purpose:

- Development of opaque armors for the defeat of direct fire, IED, and Shape Charge Jet (SCJ) threats
- Manage ManTech efforts to reduce material and processing cost of advanced armor systems
- Fabricate sub-system and prototype system level armor packages
- Provide Subject Matter Expert (SME) support to PM offices and OGAs

Requirement:

- Need for lightweight armor solutions for an increasingly weight burdened force
- Development of processes and techniques to lower cost of advanced armor systems
 - Technology is there, but not affordable
- Maturation of new armor solutions to defeat an ever changing threat set

Product:

- Lightweight B-Kit and C-Kit armor solutions that provide increased protection and are affordable
- Matured multi-threat armor solutions that are able to withstand extreme environments
- Advanced integration techniques to reduce integration burden (**scalable, modular & common**) and minimize vehicle vulnerabilities



Focused Efforts	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Receive/Develop advanced B-Kit recipe from Industry						
Design/Integrate/Mature B-Kit recipe and perform APS residual testing						
Receive/Develop advanced B-Kit and C-Kit recipes from Industry						
Design/Integrate/Mature B-Kit and C-Kit recipes						
Fastening and joining research under ballistic loading conditions						
Scalable, modular & common integration & best practices standards development						

Needs

– New alloys

- Aluminum
- Steel
- Ti

- Improved ballistic performance against both direct fire and fragmentation threats

– Ceramics

- Silicon Carbide
- Boron Carbide
- Encapsulated

- Significant cost reductions and improved manufacturing
- Improved integration techniques to minimize additional burden and increase damage resistance

– Manufacturing

- Build to print ceramics
- Advanced joining

- Automated assembly of custom ceramic parts
- Improved joining of thick section metallic (e.g. friction stir welding, laser beam welding)

– Modeling and Simulation

- Ballistic (sub-system level)
- Material models
- Further code development

- Improved M&S for ballistic events at sub-system level focusing on fasteners and joints
- High strain rate materials properties

Purpose:

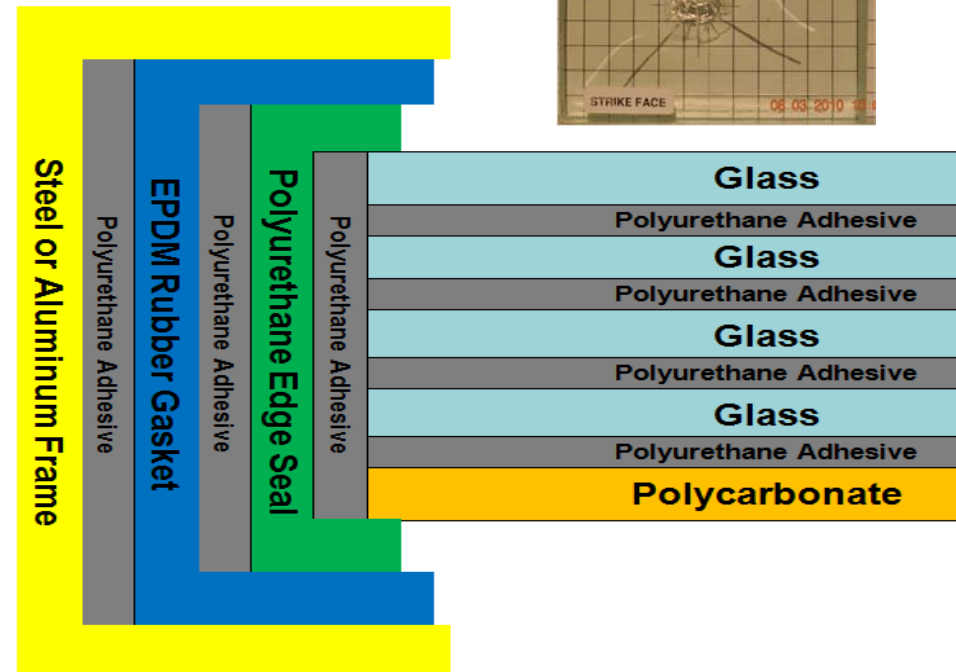
- Research and develop technologies and processes for improved performance and environmental stable transparent armor laminates
- Development of products and test procedures to improve rock-strike and delamination resistance
- Further refine ATPD 2352 to improve the overall quality of transparent armor purchased using the specification without additional cost to the Government

Requirement:

- Transparent armor provides two main functions for the Warfighter
 1. Ballistic protection from incoming threats
 2. Ability to maintain Situational Awareness
- Must be robust enough to withstand low velocity impacts (e.g. rock-strike) and extreme temperature environments with minimal loss of above capabilities

Product:

- Transparent armor laminates purchased by the Army will have improved rock-strike and environmental resistance
- Improved quality and consistency of transparent armor laminates
- Design guidance for transparent armor cross-sections and integration schemes



Focused Efforts	FY 12	FY 13	FY 14
Materials and Processing	Effects of <u>autoclave processing</u> temperature and pressure on ballistic performance	Investigation of <u>novel polycarbonate</u> materials and their effect on ballistic performance	Develop TA solution with <u>improved rock-strike resistance</u> and environmental performance
Integration Methods	Investigation of various <u>potting compounds</u> and TA coupon <u>edge wraps</u> for improved weather -ability	Investigate <u>novel integration techniques</u> and develop a recommended <u>maximum torque</u> and bolt pattern for TA	
Modeling and Simulation	Effects of <u>polycarbonate thickness and placement</u> in TA cross-section on residual part stress. Obtain high strain rate <u>materials properties</u> for polyurethane.	Effects of <u>size and shape</u> of TA on residual stress. Effect of <u>interlayer thickness</u> of residual stress and ballistic performance	Utilize <u>modeling and simulation</u> for low velocity impacts (rock-strike) investigations

Needs

– Glass

- Water white
- Glass ceramic
- Fused silica

- Improved impact and damage resistance
- Damage localization of low velocity impacts.

– Ceramics

- Spinel
- AlON

- Significant cost reductions without performance loss
- Decrease in haze; improved luminous transmission

– Interlayer Materials

- Polyurethane
- Other?

- Improved adhesion and “compliance”
- “Better” material for wide temperature range

– Backing Materials

- Polycarbonate
- Thin section Glass
- Other?

- Improved abrasion and chemical resistance
- Improved ballistic performance at low temps

Conclusion

- Who we are.
- What our mission is.
- How we plan.
- What we are investing in.
- When we plan to work these efforts.
- Ideas on how you can help us help the Warfighter.



This is the first of an annual event.....It may not be perfect, so we want the feed back to help us help you.

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