

Material Requirements and Supply Chain Analysis Of Armor Procurement For US Military Ground Vehicles



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Note: All data tables and graphs present an annual forecast from 2006 to 2013 inclusive.

1 Report Objectives

The purpose of this report is to provide a forecast of materials required to meet Department of Defense (DoD) annual procurement rates of armor for military ground vehicles (MGV's) and to provide an analysis of the supply chain that produces military ground vehicle armor and materials consumed in the production of that armor. The forecast covers a time horizon of 2006 to 2013.

This forecast addresses **armor content only** of military ground vehicles purchased by the DoD for deployment by US military services. This report and forecast does not predict material used in the construction of other vehicle components such as hulls, suspensions, engines, weapon system, electronics, etc.

The forecast is based on anticipated Department of Defense procurement rates of armor for military ground vehicles, Vector Strategy's analysis of the armor supply chain, and Vector Strategy's armor design assumptions. **It is important to note that our forecast is driven by armor procurement requirements, not annual armor production rates.** We want our clients to understand that our forecast presents the amount of material required to meet the DoD's annual procurement of armor for military ground vehicles. It does not represent a forecast of materials based on annual armor production. Please see report section 4.0 for a more detailed discussion of this point.

This report forecasts the amount in pounds weight and US dollars of various materials used in the production of armor for military ground vehicle. Materials addressed in the report include:

- Steel armor plate
- Aluminum armor plate
- Titanium
- Depleted uranium
- Transparent armor
- Ceramic powder and tiles
- Composites and materials used in the construction of composites such as resin, high performance glass fibers, aramid fibers, and HMPE fibers.
- Also included is a forecast of "other metals" and "other materials"; materials included in these categories are described in the appropriate report section.

This report provides a supply chain analysis for each of the major material components of armor for military ground vehicles. Industry structure; general characteristics of the each segment of the supply chain; an analysis of production versus requirements, backlog, and future supply and demand; and analysis of companies that participate in the supply chain segment are provided within this report as available and appropriate.

Finally, this report provides company profiles of vehicle and armor manufacturers, as well as other industry players such as composite manufacturers, producers of ballistic fibers, fabric manufacturers, and suppliers of ceramic, steel, and other metals used in the production of armor for military ground vehicles. Market shares, annual sales, products and programs supplied, recent contract awards, news releases, and strategic evaluations of suppliers is provided when available.

This report will be published once per year.

2 Distribution and Disclaimer

Clients may distribute this report freely within their single site or enterprise (one or the other) depending on the type of report license they have purchased.

- A single site license is appropriate for small to mid sized companies that conduct manufacturing or armor related activities at one principal site or location.
- An enterprise license is appropriate for large corporations who conduct armor related business in several divisions that report separately to a corporate headquarters and / or who conduct armor business through organizational structures that are sited in different physical locations.
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In addition, clients may not include reference to, or quotes from, our report in any press release or public document without our expressed approval (via email or written correspondence). If such approval is given by Vector Strategy, we request a notation in that information release that credits Vector Strategy as the original data source.

The data contained in this forecast has been obtained from sources considered to be reliable, and all analysis and comment is provided in good faith. However, no warranty is given or implied as to the accuracy or completeness of this report, and Vector Strategy, Inc. accepts no liability whatsoever for the validity and use of this data, or any consequential loss.

3 About Vector Strategy, Inc.

Vector Strategy, Inc. is a private company based in Orlando, Florida that provides market intelligence for the military armor industry. We help companies stay abreast of technology trends, government procurement, market size and growth, industry players, supply chain issues, and offer other intelligence that business executives need to make informed decisions and build effective strategic plans.

We publish a set of armor related reports and forecasts throughout the year. In addition, we offer a range of research services that allow us to meet a client's custom needs. Vector Strategy is a member of the Institute for Defense and Government Advancement and the National Defense Industrial Association.

Forecasts and reports published by Vector Strategy, Inc.:

Military Ground Vehicle Armor Forecast: This forecast addresses all tracked and wheeled U.S. military ground vehicle armor programs. Forecast reports value of armor in millions of dollars and provides vehicle and / or kit counts. Forecast period is 2007 thru 2012 with historical data for 2005 and 2006. A description of armor programs by vehicle or platform is included. This forecast was originally published in April 2007; unanticipated update published July 2007; next release in the fourth quarter of 2007.

Material Requirements and Supply Chain Analysis of Armor Procurement For Military Ground Vehicles: This report forecasts the amount (in pounds and dollars) of various materials used in the production of military ground vehicle armor. Materials addressed in the report include steel, aluminum, titanium, transparent armor, ceramics, composite materials, and ballistic fibers.

This report provides company profiles of vehicle armor manufacturers, as well as other industry players such as composite manufacturers, producers of ballistic fibers, fabric manufacturers, and suppliers of ceramic, steel, and other significant materials used in the production of military vehicle armor. Market shares, annual sales, products and programs supplied, recent contract awards, and strategic evaluations of major armor manufacturers and suppliers are provided.

Military Body Armor Forecast: This forecast addresses all components of U.S. military body armor programs. Forecast reports value of armor in millions of dollars and will provide item counts. Forecast period is 2008 thru 2012 with historical data for 2006 and 2007. A description of body armor components is included. We anticipate a January 2008 publication date.

ArmorNews: This newsletter will be published twice per month and will be distributed in electronic format. It will provide intelligence and commentary on corporate and government news related to the military armor market such as armor contract awards, corporate and government press releases, and congressional action and government statements. Special editions will cover industry conferences. The newsletter will provide commentary and analysis that business executives will find insightful and thought provoking. We anticipate initial publication in late 2007.

4 Report Methodology and Forecast Model

4.1 Description of Forecast Model and Analysis Technique

4.1.1 Forecast Based On Procurement Rates Not Production Rates

It is important to note that our forecast is driven by armor procurement requirements, not annual production rates.

We want our clients to understand that our forecast presents the amount of material required to meet the DoD's annual procurement of armor for military ground vehicles. It does not represent a forecast of materials based on annual armor production.

For several materials, the annual material requirements based on armor procurement rates cannot be met by the industrial base's capacity in that given year. Nor does it have to. In many cases, lead times for armored vehicles are greater than 12 months. In other cases, the DoD awards a contract late in their fiscal year and production relative to that contract begins in the following year (and then after 3-6 months of administrative lead time).

Although it could be arguably better to base our forecast on production rates, it is near impossible to do so with any accuracy. There is not enough detailed publicly available data regarding company sales to allow us to project the number of specific vehicles or armor kits produced by individual companies.

Thus we believe the most accurate methodology to determine material requirements related to armor procurement for military ground vehicle is to utilize annual government procurement rates for each armor system and knowledge about the design of each armor system as it can be determined from publicly available sources.

4.1.2 Description of Calculations and Forecast Model

We have developed armor design assumptions and material "recipes" for approximately 70 different armor packages (including both armor kits and integral vehicle armor) and we have developed a forecast model to allow for design changes in these assumptions on an annual basis from 2006 to 2013. I.e. perhaps today a particular kit is composed of primarily steel and aluminum; however by 2012 we believe that kit will consist primarily of composite armor. Our model can reflect this evolution in armor design at the armor package or vehicle level.

To make our projections, we have estimated the total weight of armor deployed on each vehicle, the technology and construction utilized to construct that armor, and the weight of each material within the armor system.

4.2 Sources of Information

We engage in both primary and secondary research to gather armor market intelligence. Our primary research activities include conducting interviews with armor industry participants. Interviews are conducted via telephone or in-person. We also attend major conferences and association meetings related to military ground vehicles and armor.

We also review a multitude of secondary research sources on a daily basis to stay abreast of published information relative to the armor industry. These secondary research sources include:

- Company press releases and company websites
- Congressional press releases and testimony regarding vehicle and armor programs
- Government contract awards
- Military and government press releases
- Military program office websites
- Industry trade and news publications
- Industry associations and conferences
- Industry analyst reports
- U.S. Trade and Patent Office activity
- Publications from the Congressional Budget Office (CBO)
- Publications from the White House Office of Management and Budget (OMB)
- Online sources such as www.globalsecurity.org, TankNet Military Forum, and the Federation of American Scientists (FAS) at www.fas.org.
- Online defense news services

Budget documentation we review specifically to develop anticipated procurement rates of armor kits and armored ground vehicles include:

- US Army base budget documentation released in February of each year.
- USMC base budget documentation released in February of each year.
- US Air Force base budget documentation released in February of each year.
- US Navy base budget documentation released in February of each year.
- Supplemental budgets requested by US Army, USMC, US Navy, and US Air Force.
- Congressional budget action during the fourth quarter of each calendar year.

4.3 Description of Vehicle Categories

We segment military ground vehicles into five different categories for the purpose of our forecast. Those categories are:

- Light tactical and support vehicles
- Medium and heavy tactical and support vehicles
- Armored Security Vehicles (ASV), Mine Protected Vehicles (MPV), and Mine Resistant Ambush Protected (MRAP) vehicles
- Combat vehicles
- Marine specific vehicles

Each category contains vehicle platforms from all military branches whose vehicles fit that description. For example, all HMMWV's, whether procured by the US Army, USMC, USAF, or US Navy, are included in the "light tactical vehicle" category. All medium and heavy tactical vehicles used for logistics and line haul, such as the US Army's FMTV and the USMC MTRV are included in the "medium and heavy tactical vehicle" category.

The "Marine specific vehicle" category does capture only vehicles procured by the USMC. We used the word "Marine" to describe this category not because the vehicles are procured by the USMC, but due to the mission of these vehicles. Based on mission, these vehicles don't truly fit into the other vehicle categories we defined and we believe it is best to segment them separately. It could be argued that the LAV and MPC are similar to a Stryker, and thus should be categorized together. However, for this version of our forecast, we leave our vehicle categories as defined.

Vehicle programs not covered in this forecast are:

- Construction equipment, fire fighting equipment, and material handling equipment – we included armor kits for these types of vehicles, but did not include an analysis of these vehicle platforms.
- Joint Assault Bridge, Assault Breacher Vehicle, and the USMC Heavy Recovery Vehicle – procurement quantities of these vehicles are limited over the timeframe of our forecast and thus did not warrant inclusion or analysis.

The following figure lists every vehicle platform and armor program addressed in our forecast and the vehicle category we have placed that platform or program in for our analysis.

Figure 1 - Description of Vehicle Categories and Armor Programs Covered in the Forecast**Light Tactical and Support Vehicles**

HMMWV New Vehicles - All Variants
 HMMWV Recap Program
 HMMWV Armor and Frag Kits
 Joint Light Tactical Vehicle (JLTV)

Medium and Heavy Tactical and Support Vehicles

Light Medium Tactical Vehicles (LMTV)
 Family of Medium Tactical Vehicles (FMTV)
 Family of Heavy Tactical Vehicles (FHTV)
 Medium Tactical Vehicle Replacement (MTVR)
 Logistics Vehicle System Replacement (LVSr)
 HEMTT Truck (New)
 HEMTT-ESP Truck (Recap)
 PLS Truck
 Heavy Equipment transporter (HET)
 M915A3 Line Haul Truck
 M916A3 Light Equip Transporter (LET)
 Medium and Heavy Truck Armor Kits
 Fuel Tanker Armor Kits
 Construction Equip Armor Kits

ASV's and Mine Protected Vehicles (MPV's)

Armored Security Vehicles (ASV)
 RG-31 Mine Protected Vehicle
 Cougar EOD Vehicle
 Medium Mine Protected Vehicle (MMPV)
 Mine Protected Clearance Vehicle (MPVC) Buffalo
 Vehicle Mounted Mine Detector Vehicles (VMMD)
 Mine Resistant Ambush Protected (MRAP) Vehicles
 Armor and Fragmentation Kits for ASV's, MPV's, and MRAP's

Combat Vehicles

Bradley A2 ODS Recapitalization Program
 Bradley A3 Recapitalization Program
 Bradley Reactive Tile Kits (BRAT) and IED Armor Kits
 A3 and M7 BFIST
 Stryker
 M113 A2 to A3 Conversions
 M113 Armor Upgrades and Kits
 HERCULES M88
 Abrams Frontal and Turret Armor
 Abrams ARAT, TUSK, LAGS
 Abrams M1/M1A1 Upgrade Program
 Abrams M1A2 System Enhancement Program
 FCS Manned Ground Vehicle

Marine Specific Vehicles

Expeditionary Fighting Vehicle (EFV)
 Assault Amphibious Vehicle (AAV) EAAK Armor Kits
 Marine Personnel Carrier (MPC)
 Light Armored Vehicle Upgrades (LAV-A2)
 Light Armored Vehicle Replacements (LAV-25)
 Internally Transportable Vehicle (ITV)

4.4 Description of Armor Applications

Within this forecast we segment material use by armor application. To develop this segmentation, we categorized each armor program into one of the following applications:

- **ARAT, BRAT, or Abrams Chobham Armor:** This is either add-on reactive armor tile kits or integral tank armor for tracked combat vehicles. Note that ARAT and BRAT are abbreviations for Abrams Reactive Armor Tile kits and Bradley Reactive Armor Tile kits.
- **Modular / Integral Armor:** This armor is designed as an integral part of the original wheeled vehicle. It is typically “thin-skin” or “ceramic-composite” armor that is bolted on to the vehicle's hull. Stryker, ASV, and JLTV modular and bolt-on armor are examples of programs included in this category.
- **Anti-EFP Kits:** These are programs starting in fiscal year 2008 for HMMWV, MRAP, and some combat vehicle armor kits that are designed specifically to protect against EFP threats.
- **Other Add-On-Armor Kits:** These are other add-on-armor kits that don't fall into any of the above three categories. These kits tend to be metal solutions from 2006 to 2008 and some of these programs transition slowly to composite and/or ceramic solutions from 2009 to 2013. These include kits for FMTV's and FHTV's, underbelly kits for combat vehicles, and objective gunner protection kits, for example.
- **Spall Liners:** This category includes composite panels or pan spall liners and ballistic blankets used as spall protection. We define composites in this context as fiber-reinforced rigid plastics.

5 Summary of Model Assumptions

5.1 Basis for Armored Vehicle and Armor Kit Counts

Apart from the following exceptions, the annual vehicle counts and armor kit counts provided in the July 2007 release of Vector Strategy's **Military Ground Vehicle Armor Forecast** are the basis for the armor procurement rates within this material forecast. Please refer to that document for full disclosure of annual procurement rates for armored vehicles and armor kits (**Military Ground Vehicle Armor Forecast** may be purchased separately from Vector Strategy).

5.1.1 Updated 2007 and 2008 MRAP Procurement Quantities

We have revised our MRAP annual procurement figures for 2007 and 2008 since the publication of our July 2007 **Military Ground Vehicle Armor Forecast**. The vehicle counts in the figure below are those used within this forecast to generate material requirements for MRAP vehicle armor. Please note that the vehicle count for 2008 includes those contracts awarded in October 2007 as that procurement falls in the DoD's 2008 fiscal year. To summarize, we use a 2007 procurement of XXXX MRAP vehicles and a 2008 procurement of XXXX MRAP vehicles. In addition, we have projected some continued procurement of MRAP vehicles in 2009 and beyond to sustain the fleet.

This table also presents our forecast for the procurement of anti-EFP armor kits for MRAP vehicles. We forecast that XXXX such kits will be procured in 2008, XXXX kits in 2009, and XXXX in 2010 for a total of XXXX anti-EFP armor kits for the MRAP fleet. This is our best estimate of anticipated procurement and represents our interpretation of published reports on the subject.

We identify these as "kits", but the number should be interpreted as the total number of anti-EFP armor kits that will be applied to MRAP I vehicles summed together with the number of MRAP II vehicles that will incorporate EFP protection on the vehicle production line. For example, in 2008 we believe that a total of XXXX armor kits will be procured for MRAP vehicles. Some of these will be produced as true kits and applied to MRAP I vehicles; some of these XXXX will be provided as an integral part of MRAP II vehicles.

In addition, we have segmented these kits as being based on three different armor technologies:

- XXXXXXXXXXXXXXXXXXXX
- XXXXXXXXXXXXXXXXXXXX
- XXXXXXXXXXXXXXXXXXXX

Again, please note that this is our best estimate based on published information and perhaps our intent to "cover all the bases". Regardless, these are the assumptions we use to forecast the material requirements for MRAP anti-EFP protection in this report.

Figure 2 - Assumptions of MRAP Vehicle and Anti-EFP Armor Procurement (# of Vehicles and Kits)

5.1.2 HMMWV Frag Kit 6 Procurement

The procurement of HMMWV Frag Kit 6 was not visible when we published our July 2007 **Military Ground Vehicle Armor Forecast**. Based on budget reprogramming activity occurring in October 2007, we have included the procurement of XXXX HMMWV Frag Kit 6 units in 2008 (which is supported by reprogramming activity) and forecasted procurement of XXXX additional kits in 2009. We have not forecasted the inclusion of Frag Kit 6 on new HMMWV's rolling off the production line in 2008.

5.1.3 Family of Medium Tactical Vehicles (FMTV) A and B Kit Armor Procurement

According to 2007 DoD budget documents, the Long Term Armor Strategy (LTAS) for FMTV's was to be phased into the vehicle production line during FY07. Both the FY07 base and supplemental budgets provided significant funding levels for B kit armor for this family of vehicles. In addition, a healthy procurement budget for Low Signature Armored Cabs (LSAC) was also provided in FY07.

We have seen contract awards for the procurement of LSAC's during 2007. However, the status of implementing LTAS on the FMTV is less clear to us. To be conservative, we have projected that only XX% of new FMTV's procured with fiscal year 2007 funding (base and supplemental) incorporate the LTAS and thus include A and B kits as produced. Material requirements for FMTV armor in this forecast are thus based on that assumption of XX%.

5.2 Armor Design Assumptions

A complete description of our armor design assumptions at the vehicle platform or armor kit level including specific weights and percent material content will not be released publicly. However, we would like to convey broader armor design trends and armor assumptions that help report readers understand the context in which our forecast was developed.

5.2.1 Important Distinction Regarding Our Forecast of Armor Plate Requirements

Within our forecast we do not capture metal plate (armor grade or not) that is utilized for a new vehicle's external skin, shell, or hull. We classify that use of metal plate as fundamental to the vehicle's overall content and essential to vehicle construction regardless of survivability requirements. We only capture metal armor plate requirements within our forecast model in the following circumstances:

- When metal armor plate is a component of a retrofit armor kit (such as HMMWV fragmentation kits, a BRAT kit, or an IED underbelly kit).
- When metal armor plate is a component of an armor upgrade to an existing vehicle (such as an Abrams armor upgrade during recapitalization of vehicles from M1/M1A1 to M1A2 SEP).
- When metal armor plate is a component of a modular or bolt-on armor system applied to a new vehicle (such as Stryker or ASV modular armor).
- When metal armor plate is a component of an armor kit applied to a new vehicle on the production line (such as HMMWV A and B kits).
- When metal armor plate is being applied as a supplemental liner or as an additional add-on component to a vehicle's traditional metal hull, shell, or external skin.

We define metal armor plate requirements in this manner because this forecast and report is focused on MGV armor, not the overall vehicles. Our objective is to project armor material trends over the horizon of this forecast and discuss the transition from metal armor design solutions to solutions in the future that incorporate more ceramic and composite materials. If we included metal plate (armor grade or not) utilized for a vehicle's external hull or shell, we would potentially skew our analysis towards an overstatement of metal, as least in the near term. As future military ground vehicles initiate production with all-composite or non-metal hulls, we will readdress this issue and our underlying assumptions at that time.

5.2.2 MRAP Vehicle Armor

XX

5.2.3 Spall Liners

XX

5.2.4 Transparent Armor

We report a forecast for transparent armor requirements in both square feet and pounds, and we segment transparent armor applications into two thicknesses or areal density classes:

- 2" to 3" thick transparent armor: XXXXXXXXXXXXXXXXXXXXXXXXXXXX
- 4" to 5" thick transparent armor: XXXXXXXXXXXXXXXXXXXX
- We forecasted the use of thicker ballistic glass (4" to 5") within the
XX
XXXXXXXXXX

Our forecast captures transparent armor required for new vehicle build, armor kits, and fragmentation kits.

We have also made an attempt to estimate the amount of "field replacements" of transparent armor for vehicles operating in theater. Our assumptions for field replacements are defined more fully in the transparent armor section of this report. We also include a transparent armor requirement in conjunction with the HMMWV recapitalization program.

5.2.5 Abrams Chobham (Tank) Armor

Based on information available in secondary sources, we believe that the Abrams tank is protected by armor that is similar in XXXXXXXXXXXXXXXXXXXX and that this armor incorporates the use of XXXXXXXXXXXX. Thus in this report we refer to that armor as "XXXXXXXXXXXXXXXX"

6 Forecast of Total Material Requirements for MGV Armor

Based on the assumptions and definitions we outlined previously in this report, our forecast for total material (including metals, composites, ceramics and other materials defined by our research) required to meet the DoD's annual procurement rate armor for military ground vehicles is as follows:

- We project that 2007 material requirements are XX million pounds and 2008 requirements are XX million pounds. (Note: please read the previous report section on assumptions to understand the armor plate requirements we include and exclude from our forecast).
- By 2013, we believe that only XX millions pounds of material will be required to meet armor procurement for military ground vehicles based on armor and vehicle programs with visibility today.

The surge in 2008 is due to increased procurement of XXX vehicles and the procurement of EFP protection for those XXXX's and also XXXXX's.

The decline through 2013 is due to two factors, equally important:

- First, we are projecting a decrease iXXXXXXXXXXXXXXXX XXXXXXX XXXXXXX
- Secondly, we are projecting a transition to XXXXXXXx XXXXXXX armor solutions over the horizon of the forecast.

The second factor mentioned above is driven by a transition from metallic armor solutions to non-metallic or composite armor solutions and a transition from steel to lighter weight metal solutions. Note that in this context, we are using "composite" to mean an armor design composed of multiple materials including ceramic, metal, and fiber-reinforced rigid plastics. This latter topic will be discussed in more detail in a subsequent report section.

We have forecasted "supplemental" spending for armor in 2009 and beyond, but our forecast will be conservative if US involvement in the current conflict in Iraq and Afghanistan continues at the current level of engagement rather than declines starting in late 2008 / early 2009.

6.1 Materials Forecast by Type of Material (in Pounds – Weight)

The following paragraphs provide a brief introduction to the absolute and relative requirements of each material covered in our forecast and some initial comments regarding trends driving those requirements. Each material is discussed in detail in subsequent report sections along with an analysis of the supply chain related to that material.

In addition, at the end of this report section is a figure that provides annual procurement requirements for each material.

Steel Armor Plate. XX of 2007 material requirements are for steel armor plate; this material component represents a procurement related demand of XX million pounds in 2007. Steel armor plate requirements decline slightly in 2008 to XX million pounds due to substitution with aluminum and slightly lower procurement of new XXXXX's in 2008 versus 2007.

Aluminum Armor Plate. Requirements for aluminum armor plate XXXX from XX% of total material requirements or XX million pounds in 2007 to XX% of total requirements of XX million pounds in 2008. Substitution for steel and increased XXXXX and armor kits for XXXX are drivers of increased aluminum requirements.

Titanium and Depleted Uranium. These materials are included in our forecast, but represent only XXXXX of total material requirements by weight. Requirements for these materials are discussed more fully in subsequent report sections.

Other Metals. Currently the only "other metal" we have defined in our forecast is P-900 cast steel plates for armor kits. We've projected a requirement for this material in 2008, and a more limited requirement in 2009 and 2010. This material only represents XX of total material requirements in 2008 and is discussed more fully in a subsequent report section.

Ceramic Materials. Ceramic materials represent XX million pounds or XX% of total material requirements. By 2013, we forecast that ceramic materials will represent XX million pounds or XX% of total material requirements. Drivers for the increased demand in 2013 include XXX armor and a XXXX XXXX solutions over the horizon of the forecast. Subsequently in this report you will find a discussion of aluminum oxide versus silicon carbide ceramic requirements.

Composites.

Transparent Armor.

Other Materials.

Example of a report section on a specific material type.

16 Composite Manufacturers

16.1 Description and Characteristics of Composites Supply Chain

These companies manufacturer composites used in the production of armor for ground vehicles. These composites made be a solid panel of reinforcing fiber or cloth in a polymer matrix used as a spall liner or ballistic panel within a vehicle armor system. We also include in this material category composite backplates used within ceramic armor solutions; the fiber/resin component of any ceramic/metal/composite armor solution for military ground vehicles; and ballistic blankets used as vehicle spall protection.

The overall composite industry can be segmented into the following three board categories:

Consumer Composites: Boats, automobiles, and recreational products.

Industrial Composites: Storage tanks, piping, pressure vessels, etc.

Advanced Composites: Aerospace composites, including military and commercial aircraft composites, armor and ballistic / blast applications, and high performance sporting equipment. Advanced composites are characterized by the use of more expensive, high performance resin systems and high-strength, high-stiffness fiber reinforcements.

Companies that manufacturer armor composites typically fall into one of the following scenarios:

- They are a captive, in-house composite operation within a large vertically integrated armor manufacturer. Simula of BAE Systems / Armor Holdings is an example of such a composite manufacturer. General Dynamics Armament and Technical Products and ArmorWorks are examples of other armor manufacturers with captive composite manufacturing capabilities.
- They are a company that primarily produces composite panels or kits to specifications provided by their customers. They typically provide cutting, finishing, and machining services; but may not integrate the composite panels into a vehicle or finished armor system. These companies are also likely to manufacturer advanced composites for the aerospace and aircraft industries. Examples of these companies include M.C. Gill and TPI Composites.
- They are a company that specializes in armor kits, addressing both the civilian and military markets, as well as vehicle and body armor applications. Sioux Manufacturing, L&L Armor Systems, and Protech Armored Products are examples of this type of composite manufacturer.

16.2 Requirements in Pounds (Weight) of Composites for MGV Armor

16.2.1 Overall Forecast of Composites

The data table on the following page presents our forecast for composites required to meet the DoD's annual procurement rate of armor for military ground vehicles.

- 2007 requirements for composite material are xxx million pounds.
- 2008 requirements for composite material are XXX million pounds.
- By 2013, we forecast that the market will require XX millions pounds of composites. This is below the peak created in 2008 due to XXX vehicle XXXX, but a figure driver higher than 2010-2011 requirements by production for XXXX and XXXX armor.

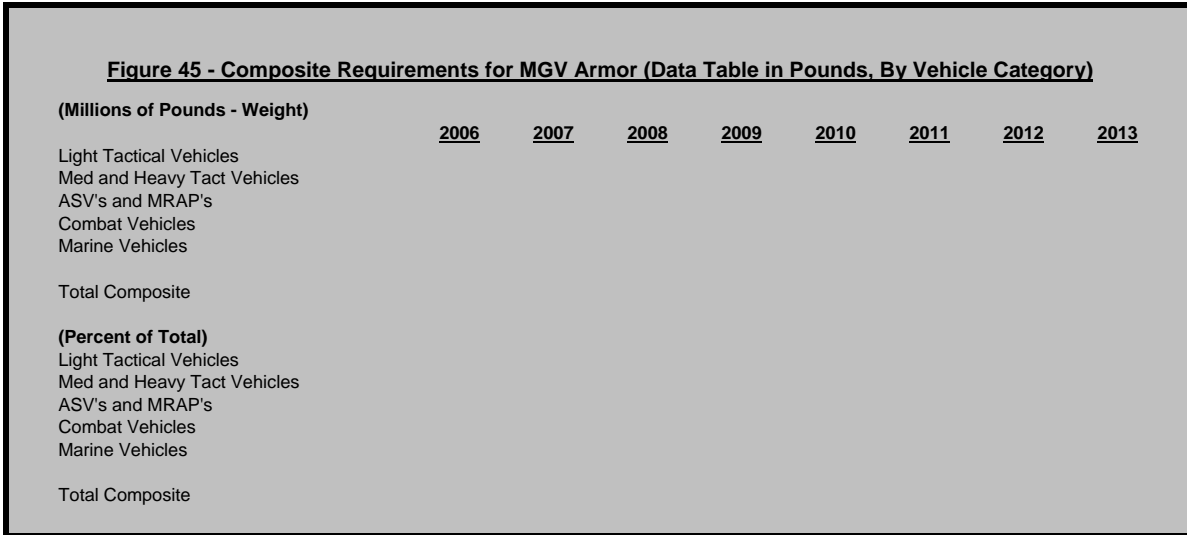
16.2.2 Forecast of Composites By Vehicle Category

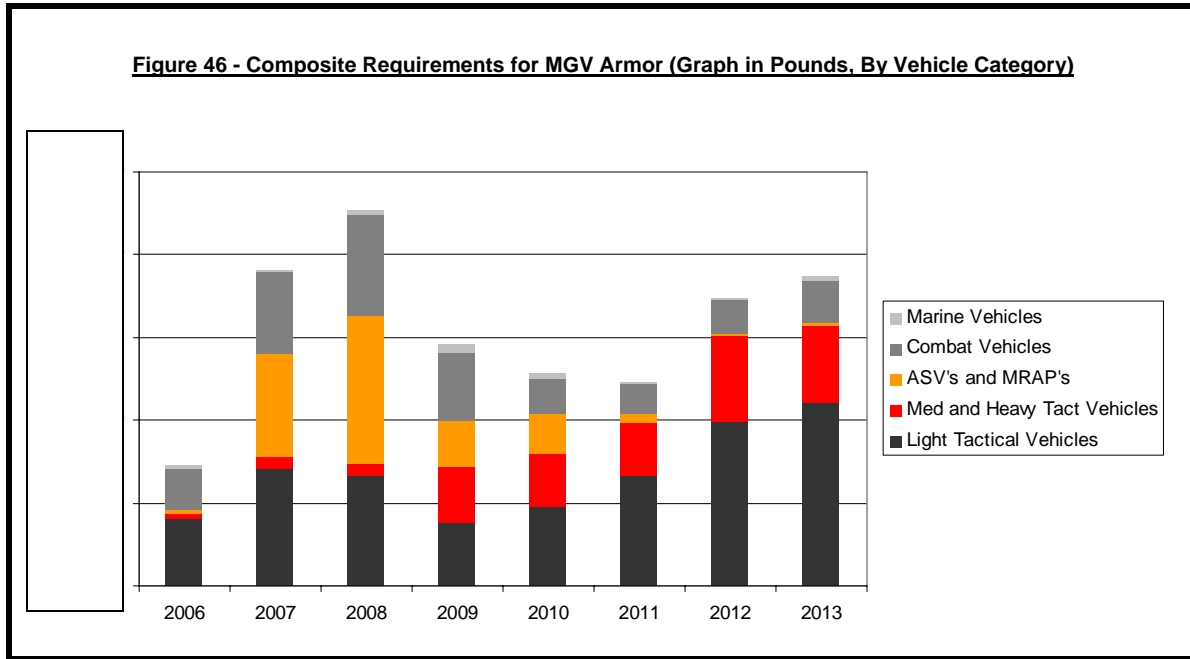
Total composite requirements in 2007 and 2008 are segmented as follows:

- Light tactical vehicles: % of total composite requirements in 2007 and % in 2008.
- Medium and heavy tactical vehicles: % in 2007 and % in 2008.
- ASV's and MRAP vehicles: % in 2007 and % in 2008.
- Combat vehicles: % in 2007 and % in 2008.
- Marine specific vehicles: % or less in both 2007 and 2008.

Observations on trends over the horizon of the forecast include:

- XXXXXXXX drive the market significantly in 2008.
- In 2009 we have forecasted that composite armor will be initiated in XXXXXXXX armor kits. This vehicle category drives a moderate demand for composites through the remaining forecast period.
- By 2011 the XXXXXXXX starts to create an up-tick in composite demand in the XXX vehicle category.





16.2.3 Forecast of Composites By Armor Application

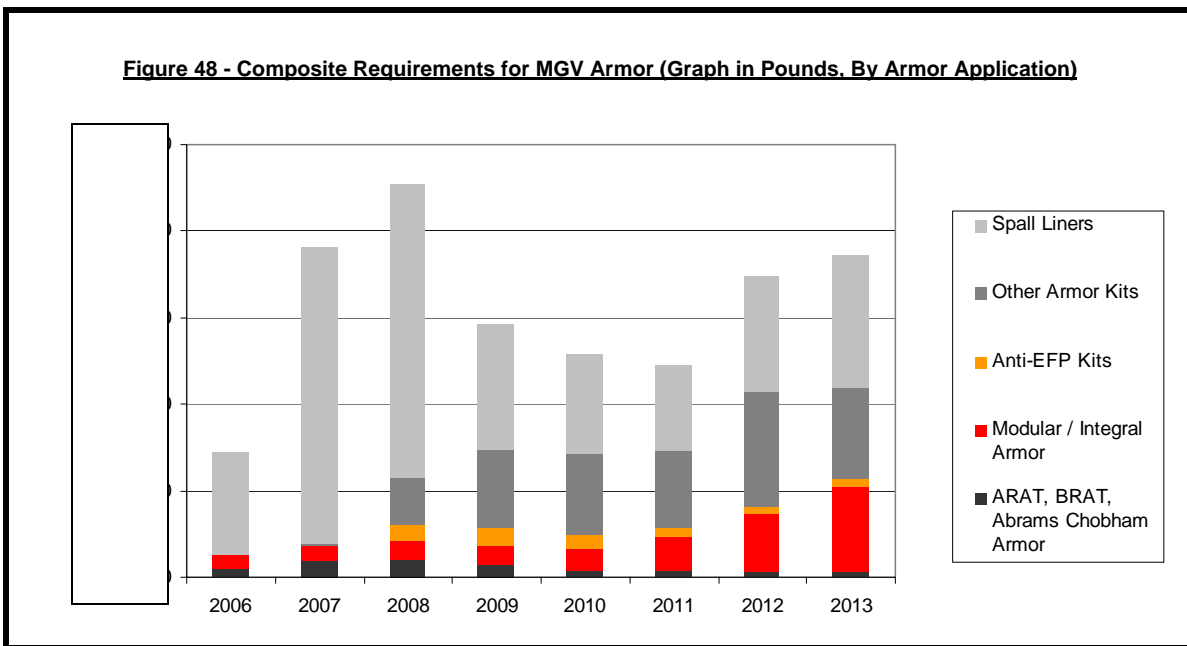
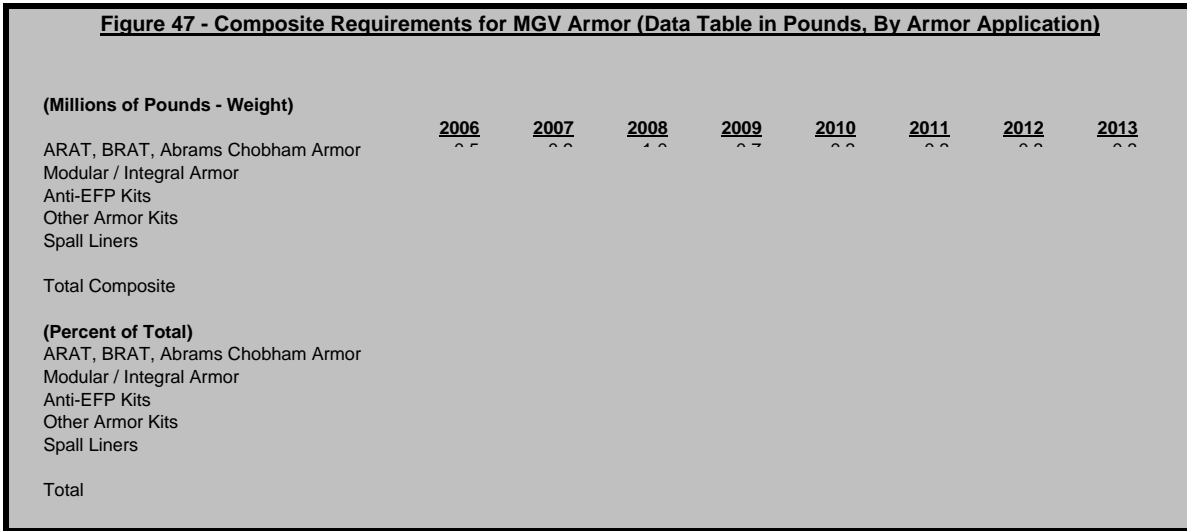
The following data table and graph present the requirements in pounds (weight) for composite material by type of armor application.

Observations from the following figures which analyze composite requirements by armor application:

- XXXXXXXXXXXx consume the greatest percentage of total composite requirements in 2006, 2007, and 2008; representing %, %, and % of all composite requirements in each of those years respectively.
- In 2008, XXXX kits and the transition of some components of XXXXX kits to composite materials influence demand.
- In 2009, we began to incorporate composites into some XXXXXX armor kits.
- In 2011, we start to see the influence of XXX armor, which we assume will be a ceramic/composite solution, in this market.

Specific vehicle and armor programs that are significant drivers of composite material requirements in 2007 and 2008 are:

- XXXXXXXX
- XXXXXXXX
- XXXXXXXXXXXX
- XXXXXXXXXXXXXx
- XXXXXXXXXXXXXXXX (potentially)



16.2.4 Forecast of Composites By Type of Reinforcing Fiber

Based on our armor design assumptions we can segment total composite requirements by type of reinforcing fiber. We do offer some cautions or caveats, however, as you review that segmentation:

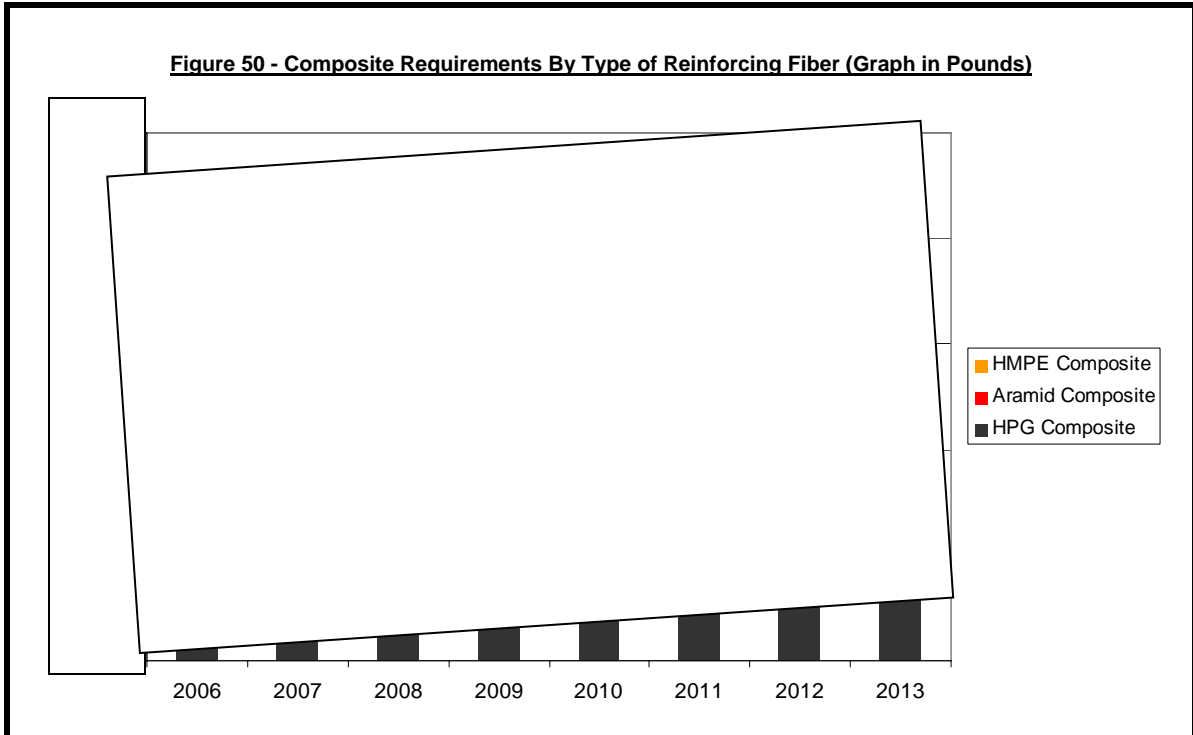
- XXXXXXXXXX

- XXXXXXXXXXXXXXXXXXXXXXXX

As the following figures present, in 2007, we project that % of the composite used for MGV armor applications are reinforced with HPG fiber and % of composites are reinforced with aramid fibers. By 2013, that ratio has changed to % HPG fiber reinforced composite, % aramid fiber reinforced composite, and % HMPE fiber reinforced composite.

Figure 49 - Composite Requirements By Type of Reinforcing Fiber (Data Table in Pounds)

(Millions of Pounds - Weight)	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>
HPG Composite								
Aramid Composite								
HMPE Composite		-						
Total Composite								
(Percent of Total)								
HPG Composite								
Aramid Composite								
HMPE Composite		-						
Total Composite								



16.3 Market Value (US\$) of Composites for MGV Armor

The following figure presents our estimate of the market value in US dollars (\$) of composites required to meet DoD procurement rates for MGV armor from 2006 to 2013.

Figure 51 - Market Value of Composite Requirements For MGV Armor (Data Table in US\$ Millions)

(US\$ Millions)	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>
HPG Fiber Composite								
Aramid Composite								
HMPE Composite								
Total Composite Value								

Note the following observations:

- We estimate that to meet 2007 armor procurement requirements, the value of required composites would be \$XX million.
- This increases to \$XX million in 2008 due to increased XXXXXX applications, the inclusion of composites in some XXXXX designs, and the implementation of composites in some XXXXXXXXXX armor kits.
- By the end of our forecast period (2013), we estimate that the value of composites required to meet MGV armor procurement rates will be \$XX million, less than the market's peak in 2008, but still a substantial market for composites.

Composite market value is calculated by multiplying the pounds of composite reported in the previous report section by a cost per pound based on composite type (i.e. a different cost per pound was utilized for HGP fiber reinforced composite, aramid fiber reinforced composite, and HMPE reinforced composite). Our forecast is calculated based on constant dollar value (2007).

16.4 Composite Production Versus Requirements and Backlog Discussion

The American Composites Manufacturers Association (ACMA) states in their 2006 Composite Industry Report that the US composites industry generates revenues of \$16 to \$20 billion per year, is comprised of 5,000 to 7,000 composites related manufacturing plants and distributors, and in 2006 produced 4.5 billion pounds of composites for all markets (consumer, industrial, and advanced composites).

As stated previously, we forecast that the amount of composites required for MGV armor applications is XX million pounds in 2007 and XX million pounds in 2008. Even in 2008 at composites peak requirements demand, composites for MGV armor represents XXXXXXXXX% of total composites produced in the U.S.

Based on this assessment, we believe that there is sufficient capacity within the composites industry to manufacture the amount of material required for this market. If manufacturers of advanced composites are given adequate lead time and there is availability of fiber and resin, we believe this segment of the supply chain will not be a bottleneck for armor production and fielding.

16.5 Discussion of Significant Armor Composite Manufacturers

As stated previously in this report section, companies that manufacturer armor composites typically either represent the captive, in-house composite operation of a large vertically integrated armor manufacturer; they may be a company that primarily produces composite panels or kits to specifications provided by their customers and may also serve other industries; or they are a company that specializes in armor kits. Couple those possibilities with the 5,000 to 7,000 ACMA estimated composite manufacturers in the U.S. and one could develop an extensive list of potential composite armor manufacturers.

In the last section of this report we provide company profiles on several composite manufacturers that do participate in the armor supply chain. We are not able to provide market share estimates of composite armor manufacturers due to the diversity of the industrial base, but the following table lists composite companies that do actively participate in this market. We have noted which companies in the table are covered with a company profile in the last section of this report.



22 Company Profiles

22.1 Company Profile Introduction and Disclaimers

The companies covered in this report section were chosen either because they are a significant participant in the MGV armor industry or because they fairly represent a particular type of company we describe in this report. Companies did not pay an advertising fee to appear in this report, nor does our coverage of any company indicate that they may or may not be a client of Vector Strategy, Inc. The inclusion or exclusion of any company in this report section does not indicate our assessment of their market share or sales within the MGV armor market.

These company profiles are based on publicly available data and secondary research. In some cases, we were able to reach a representative of a company and include comments and clarifications from that individual. We were not able to contact all companies and some that we did contact chose not to respond to our inquiry.

The information provided on each company is for informational purposes only and has been obtained from sources believed to be reliable and all analysis and comment is provided in good faith. However, no warranty is given or implied as to the accuracy or completeness of these profiles, and Vector Strategy, Inc. accepts no liability whatsoever for the validity and use of this information, or any consequential loss.

These profiles were completed between September 15, 2007 and October 15, 2007. Thus, news and contract awards occurring since September 15, 2007 may or may not be included in any specific company profile.

Finally, we did not include trademark symbols, i.e. "®" in our report or company profiles next to trade and brand names. Our intent in omitting them was not to minimize their importance, but to facilitate ease of reading and report formatting.

The following pages contain two company profiles as examples of this section of the report.

22.4 AGY

Market Participation: Fiber Manufacturer							
Website: www.agy.com							
Ownership: Large Private Company	Stock Symbol: Not Applicable						
<p><u>AGY Description</u></p> <ul style="list-style-type: none"> • AGY Holding Corp, a C corporation incorporated in Delaware, is the reorganized corporate structure of the business formerly conducted by Advanced Glassfiber Yarns LLC and its subsidiaries. After emerging from Chapter 11 in 2004, the company reorganized and changed its name. In April 2006, the company was acquired by Kohlberg & Co. LLC (Mt. Kisco, N.Y.), a private equity firm for approximately \$268 million. The business is now conducted through AGY Holding Corp, its two wholly owned domestic operating subsidiaries, AGY Aiken LLC and AGY Huntingdon LLC, and its two wholly owned foreign subsidiaries, AGY Europe SARL and AG Yarns Canada Inc. • AGY produces E Glass and S-2 Glass yarns, which are thin filaments of glass twisted together to form yarn and high strength fiberglass reinforcements used in a wide variety of composites applications. Originally developed for military applications in the 1960's, S-2 Glass was first introduced to the commercial market in 1968. Initially compatible with epoxy resins, the product's compatibility has been expanded to include thermoplastics, polyesters and vinyl ester resins. AGY's fiberglass yarns are used in applications for defense, aerospace, automotive, construction, electronics, recreation, and other industrial markets. Among defense products, the company offers the proprietary hard armor HJ1 system that utilizes S-2 Glass rovings in composite panels built into US military HMMWV's, and other armored vehicles for ballistic protection. S-2 Glass products are made exclusively by AGY. • High performance fiberglass offers outstanding ballistic protection and structural performance for hard composite armor applications due to the high tensile and compressive strengths of S-2 Glass fibers. The fiber's high ultimate elongation plays an important role in the dynamic ballistic impact-absorbing mechanism. Structural performance, protection against fire and smoke, and reduced costs without sacrificing ballistic performance are key factors considered when choosing S-2 Glass for the defense market. 							
<p><u>AGY Locations / Divisions</u></p> <table> <tr> <td>Aiken, SC</td> <td>AGY World Headquarters is the central location for sales and marketing, finance and accounting, customer service, human resources, and technology. The Aiken site also houses manufacturing facilities and the central technology center, which is the heart of technology development for products and processes.</td> </tr> <tr> <td>Lyon, France</td> <td>European Office</td> </tr> <tr> <td>Huntingdon, PA</td> <td>Manufacturing</td> </tr> </table>		Aiken, SC	AGY World Headquarters is the central location for sales and marketing, finance and accounting, customer service, human resources, and technology. The Aiken site also houses manufacturing facilities and the central technology center, which is the heart of technology development for products and processes.	Lyon, France	European Office	Huntingdon, PA	Manufacturing
Aiken, SC	AGY World Headquarters is the central location for sales and marketing, finance and accounting, customer service, human resources, and technology. The Aiken site also houses manufacturing facilities and the central technology center, which is the heart of technology development for products and processes.						
Lyon, France	European Office						
Huntingdon, PA	Manufacturing						

AGY Financial PerformanceSales History and Projections (\$ in Millions of US dollars)

	<u>2005</u>	<u>2006</u>	<u>Six months ended June 30, 2007</u>	<u>2007E</u>
Total Company	\$160.6	\$170.6	\$86.4	N/A

Fiscal Year End: December

Discussion of Sales

- The sales numbers above reflect total company net sales. The company does not provide sales by market or application. Per a company press release dated 1/22/07, the increase in 2006 net sales was due to improved pricing conditions and increased sales to some of AGY's higher margin markets and applications including defense (39% increase) and specialty electronics (14% increase), resulting in a favorable product mix compared to 2005.
- In a company press release dated 8/13/07, AGY reported second quarter net sales of \$48.6 million in 2007 versus \$43.5 million in 2006, a year-over-year increase of 12%. Sales for the six month period ending June 30, 2007 were \$86.4 million versus \$87.8 million for the same period in 2006. The company states that the second quarter sales increase was the result of increased demand in its more profitable end-markets, including electronics and defense (particularly demand associated with MRAP vehicles), partly offset by decreased demand in the industrial market and the construction market.

Profitability History and Projections

- We will not report a profitability metric for AGY, due to the company's complex accounting issues including non-cash compensation charges, a net non-cash alloy depletion charge, and acquisition costs.

Source of Financial Information

SEC / Annual report	<u>X</u>
Financial analyst report	
Dun and Bradstreet, Hoovers, etc.	
Provided by company	<u>X</u>
Estimated	

Number of AGY Employees: The company has 1,100 employees, per Dun & Bradstreet.

Major Vehicle and/or Armor Programs That Incorporate AGY's S-2 Glass

- MRAP spall liners
- HMMWV spall liners and other composite applications
- Littoral Combat Ship (LCS) vessels - US Navy ships for coastal and shallow-water missions, focusing on high-speed maneuverability, agility and sprint speed
- HMMWV Helmet Hardtop - a field-installable composite cover providing ballistic protection for personnel and equipment in the back of a HMMWV
- Landing Helicopter Deck (LHD) ships - built for the US Navy and the largest amphibious assault vessels in the world
- Expeditionary Fighting Vehicle (EFV) - a self-deploying, high-water-speed, armored amphibious vehicle capable of transporting US Marines from out-of-sightline ships to inland objectives
- Stryker - a family of eight-wheel-drive combat vehicles built for the US Army

AGY News and Acquisitions

- Per a news clipping on 9/7/07, AGY has entered into a definitive agreement to acquire Owens Corning CFM manufacturing assets in Huntingdon, PA and marble production assets in Anderson, SC. The transaction, which has been approved by AGY's Board of Directors, is expected to close in late 2007 and is subject to customary closing conditions and regulatory and antitrust approvals.
- Per a company press release dated 6/1/07, AGY has developed a competitively priced unidirectional fabric made of S-glass, using its ZenTron roving, which will enable commercial boat builders to begin using the material instead of E-glass. ZenTron roving is a single-end product, with an epoxy-compatible sizing that is less expensive than assembled S-glass yarns.
- Per a company press release dated 4/10/07, new applications for composite armor systems in EOD suits and vehicles continue to drive the growth of S-2 Glass reinforcements. The company said it shipped a record amount of the material in 2006 and expects to surpass that record in 2007.
- Per a company press release dated 3/28/06, the US Navy's first Littoral Combat Ship (LCS) will have HJ1 composite armor made with S-2 Glass roving from AGY. The USS Freedom, designed by Lockheed Martin, will be the first US ship to carry the LCS class designation. The US Navy has plans to build a total of 60 LCS class ships during the next 10 years. The LCS ship is the second major naval program for S-2 Glass and HJ1 armor. Landing Helicopter Deck (LHD) class vessels built by Northrup Grumman also use the HJ1 armor system.
- Per a company press release dated 3/28/06, AGY applied for patent protection for an improved ballistic system using a new S-2 glass reinforcement. The new product is delivered to converters as an assembled or multi-end roving. Composites made with the new fiber will have similar mechanical performance but yield a 5% to 10% boost in ballistic protection capability. The improved fiber offers increased performance and lighter weight composites.

AGY Capital Expenditures and Investments

- In a company press release dated 3/28/06, the company stated plans to increase S-2 Glass reinforcement capacity in the next 18 months. The expansion plans include: new forming equipment to increase fiber capacity by 50%, an 80% increase in winding and processing equipment for roving, and a goal to raise manufacturing productivity by 15% in 2006. In 2005, AGY increased overall capacity for S-2 products by 35%.

Strategic Discussion of AGY

- AGY's manufacturing technology is easily scaleable. The company monitors and projects demand carefully, and invests in capacity expansion ahead of their products' demand curves. The company states that they currently have enough capacity to fulfill anticipated requirements and product growth as foreseen for the next 3 years.
- AGY plans to continue their focus on high performance materials and applications. AGY's S-2 Glass products have an established history within military ballistic applications and the company plans to continue to address this market with new solutions and partnerships in the future.

22.28 General Dynamics Armament and Technical Products

Market Participation: Reactive Armor Manufacturer

Website: www.gdatp.com

Ownership: Unit of Public Company

Stock Symbol: GD (Parent Company)

General Dynamics - ATP Description

- General Dynamics Armament and Technical Products (GDATP) headquartered in Charlotte, N.C., provides a range of system solutions for military and commercial applications. The company designs, develops and produces armament systems; advanced composite-based products; biological and chemical detection systems; and mobile shelter systems.
 - Advanced Materials: GDATP produces a broad range of products using advanced, lightweight materials. Our advanced materials include a diverse range of composite structures such as vehicle-mounted shelter systems, aircraft radomes, internal and external aircraft structural components, and an array of mission-critical pressure vessels.
 - Detection Systems: GDATP is a leading producer and system integrator of biological and chemical detection systems. GDATP offers on-site and long-range detection sensors to provide our customers with flexible detection capabilities.
 - Gun Systems: GDATP has over 50 years of experience manufacturing gun systems for the U.S. Military's land, air and sea applications. Through proven manufacturing methods and a dominant position in the market, GDATP has applied decades of aircraft gun system manufacturing expertise to a broadening line of advanced Individual and Crew Served weapons systems, including the 40mm MK47 and the 25mm and 12.7mm Advanced Crew Served Weapon.
 - Weapon Systems and Armor: GDATP is a leading manufacturer and system integrator of proven and next-generation weapon systems for land, air and sea applications. GDATP produces reactive armor, 2.75-inch rockets, and a broad range of naval weapon systems.
- General Dynamics Corporation, the parent company of GDATP, is headquartered in Falls Church, Virginia, and employs approximately 82,900 people worldwide. They anticipate 2007 revenues of more than \$27 billion. The company provides products and services directed at business aviation; land and expeditionary combat systems, armaments and munitions; shipbuilding and marine systems; and information systems and technologies.

General Dynamics ATP Locations:

The LakePointe Office Center
Charlotte, NC

Executive Office for GDATP senior leadership, including business development, strategic planning, finance, human resources, administration and product-oriented business teams.

Stone County Operations,
McHenry, MS

This location is a reactive armor tile integration facility providing assembly, integration, and storage capabilities in 55,000 square feet. In addition to advanced pneumatic palletization and assembly methods, Stone County Operations also provides hardware storage, cassette and tile assembly, seal, paint, box, pack, store, and ship capabilities.

Charlotte Operations Charlotte, NC	The Charlotte Operations provides development, manufacturing and integration of advanced biological and chemical agent detection systems in approximately 100,000 square feet of manufacturing and office facilities, with an additional 23,000 square feet of expansion space.
Burlington Technology Center Burlington, VT	The Burlington Technology Center is GDATP's engineering center. The technology center campus encompasses five sites, including the Lakeside office building, a 13,500-square foot Engineering Development Lab, the Systems Modernization Initiative office, the Burlington manufacturing site and a test facility. This location houses also offices for companies and partner institutions, such as BAE Systems and the University of Vermont, and a secure conference room for meetings with officials from the Department of Defense.
Saco Operations Saco, ME	GDATP's core production facility for single-and multi-barrel aircraft and crew-served weapon systems, in approximately 450,000 square feet of manufacturing space.
Marion Operations Marion, VA	Marion Operations produces composite structures, mobile shelter systems, high-performance radomes, and the company's Resin Transfer Molding products. Marion Operations has approximately one million square feet of manufacturing space at three facilities.
Lincoln Operations Lincoln, NB	Lincoln Operations produces a wide range of composite structures for aerospace and defense markets, with approximately 175,000 square feet of manufacturing and office space.
Camden Operations Camden, AR	The Camden facility is dedicated to rocket and munitions load, assemble, and pack operations, with approximately 550,000 square feet of manufacturing and storage space.

General Dynamics ATP Financial Performance

Discussion of Sales

- Financial analysts estimate that GDATP's total unit sales for 2007 will be approximately \$1.0 billion with the following breakout by product:

Detection systems:	35% or \$350 million
Weapon systems and armor:	35% or \$350 million
Advanced materials:	15% or \$150 million
Gun Systems:	15% or \$150 million

Source of Financial Information

SEC / Annual report	
Financial analyst report	<u>X</u>
Dun and Bradstreet, Hoovers, etc.	
Provided by company	<u>X</u>
Estimated	

Number of General Dynamics ATP Employees

- Vector Strategy estimates that GDATP employs approximately 2,500 people.

General Dynamics ATP Major Armor Programs

- General Dynamics Armament and Technical Products, in conjunction with Rafael Ordnance Systems Division, has developed and is manufacturing reactive armor tile kits for application on the Abrams M1A1 Tank and Bradley Fighting Vehicle System. This armor incorporates an insensitive high-energy explosive as part of the armor design to protect against anti-tank threats.
- The production management for these reactive armor programs is conducted from General Dynamics Armament and Technical Products' Burlington Technology Center, Burlington, Vt., with U.S. tile production occurring at the company's reactive armor facility in Stone County Operations, McHenry, Miss.

General Dynamics ATP Significant Contract Awards

- 8/20/07 - \$107.7M contract option from the U.S. Army TACOM-Picatinny for reactive armor production for the Bradley Fighting Vehicle. This option is part of a July 2006 contract and brings the total value to \$237 million. GDATP's strategic partner, RAFAEL Armament Development Authority Ltd., Ordnance Systems Division (Haifa, Israel), will share 50 percent of the production workload. The production program will be managed from the General Dynamics Armament and Technical Products, Burlington Technology Center, Burlington, VT., with U.S. tile production occurring at the company's reactive armor facility in Stone County Operations, McHenry, MS. Work under this contract will continue through September 2009.
- 1/4/07 - \$29M from U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny, N.J., for the production of reactive armor tile sets to equip Abrams tanks. This award modifies a contract originally awarded in August 2006 and brings the total contract value to \$59 million. The production program will be directed from General Dynamics' Vermont-based Burlington Technology Center, with tile production occurring at the company's facility in McHenry, Miss.
- 8/28/06 \$30M million competitive contract from U.S. Army Tank Automotive and Armaments Command (Picatinny, N.J.) for the production of reactive armor tile sets to equip Abrams tanks. Total contract value could reach \$59 million if all contract options are exercised. The production program will be directed from the General Dynamics Armament and Technical Products' Burlington Technology Center, Burlington, VT., with U.S. tile production occurring at the company's reactive armor facility in Stone County Operations, McHenry, MS. Work will be completed by August 2009.

Strategic Discussion of General Dynamics - ATP

- Analyst reports state that GDATP's management seems open to consider acquisitions for future growth and that sales of this unit may stagnant unless GDATP expands into the commercial aerospace composite structure market and / or recaptures lost share in the counter-IED market.
- GDATP needs to protect their dominance of the U.S. reactive armor market and should leverage this technology to counter EFP threats and offer solutions for other vehicle platforms.