VECTORPLY®
PERFORMANCE COMPOSITE REINFORCEMENTS

Perspectives on Emerging Composite Technologies from a Materials Supplier

Trevor Gundberg, P.E.
Director of Composites Engineering
September 15, 2016

Presentation Outline

- Introduction to Vectorply
- End Use Markets Served & Composite Technologies Utilized
  - Marine
  - Infrastructure Rehabilitation
  - Industrial/Corrosion
  - Aerospace/Defense
  - Automotive

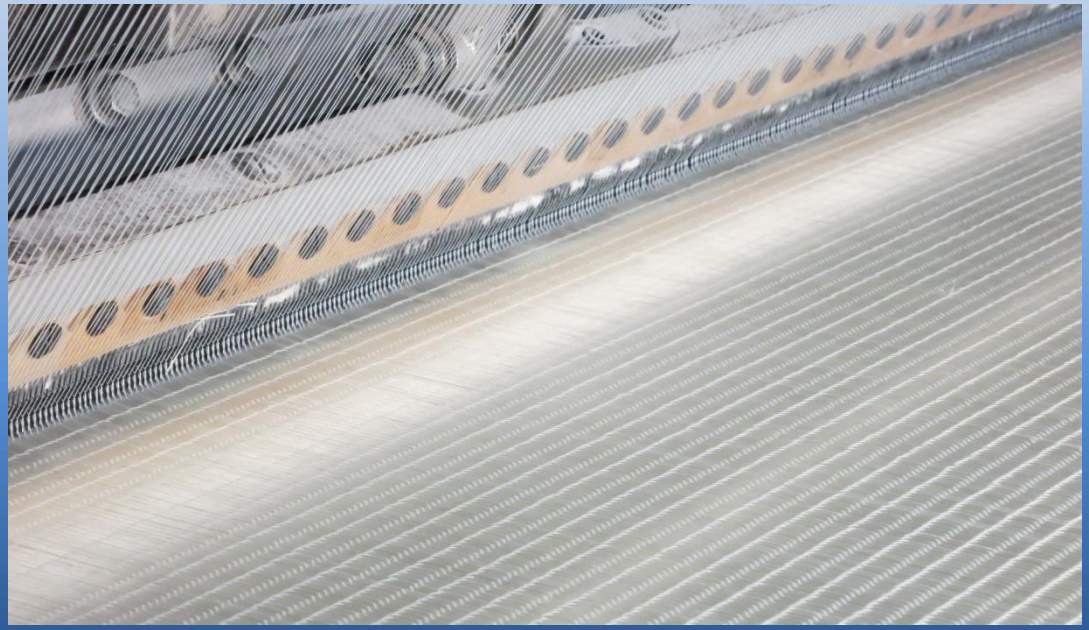
VECTORPLY®
PERFORMANCE COMPOSITE REINFORCEMENTS

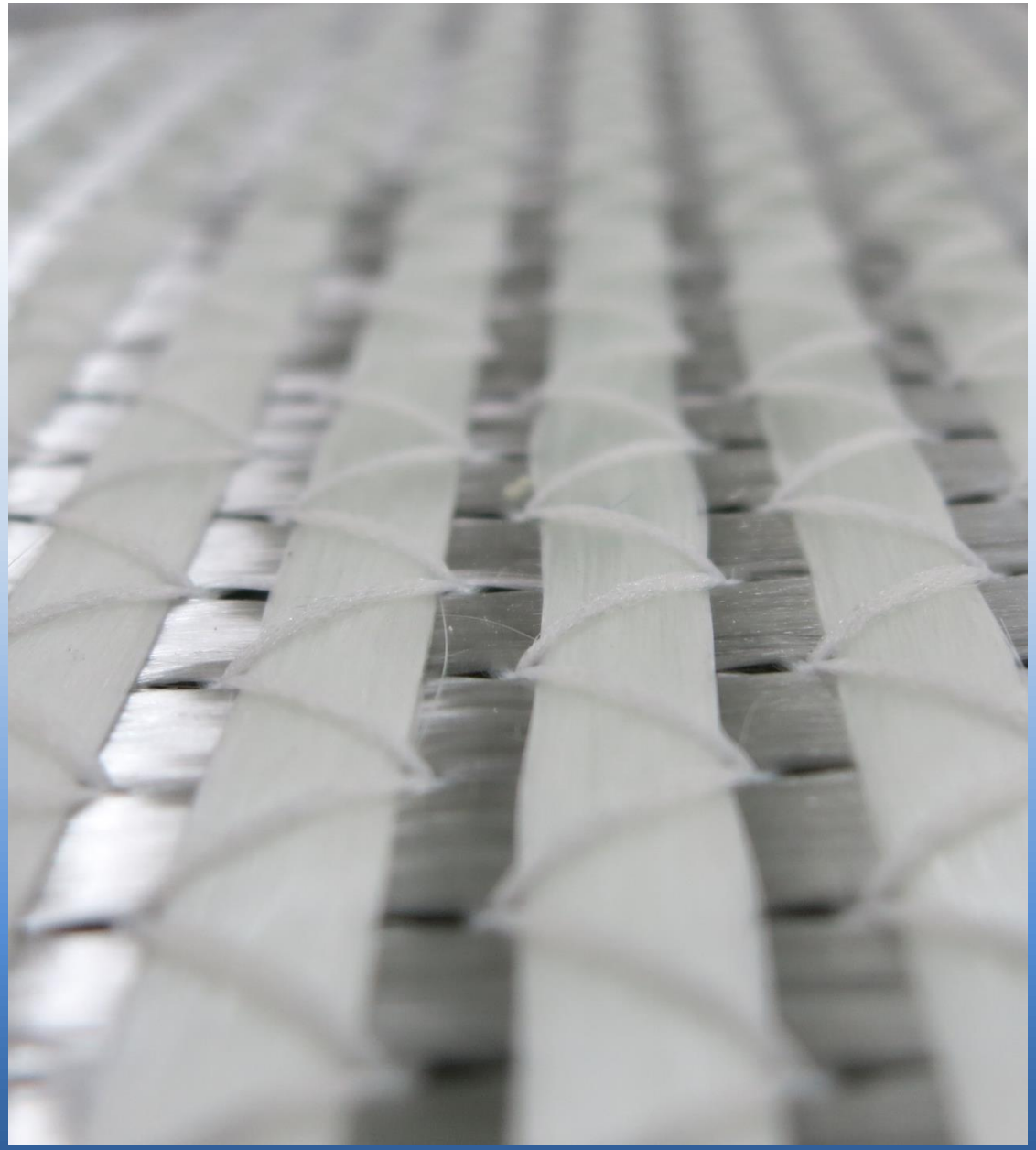
ALABAMA FACTORY

- 120,000 FT² OF MFG. SPACE
  - ADDITIONAL 50,000 FT² COMING APRIL 2017
- 24 MACHINES (LIBA & MAYER)
- 112 EMPLOYEES
- 3 SHIFTS – 6/7 DAYS PER WEEK
- PRODUCING 500+ FABRIC STYLES
- CAPACITY IN PLACE TO PRODUCE 65 MILLION POUNDS

What We Do

Fibers such as E-glass, aramid and carbon are assembled into fabric using warp knitting technology. The fibers are kept straight which provides higher levels of physical performance compared to chopped mat or woven roving. The straight fibers may be placed on specific angles as needed to optimize performance and minimize cost.



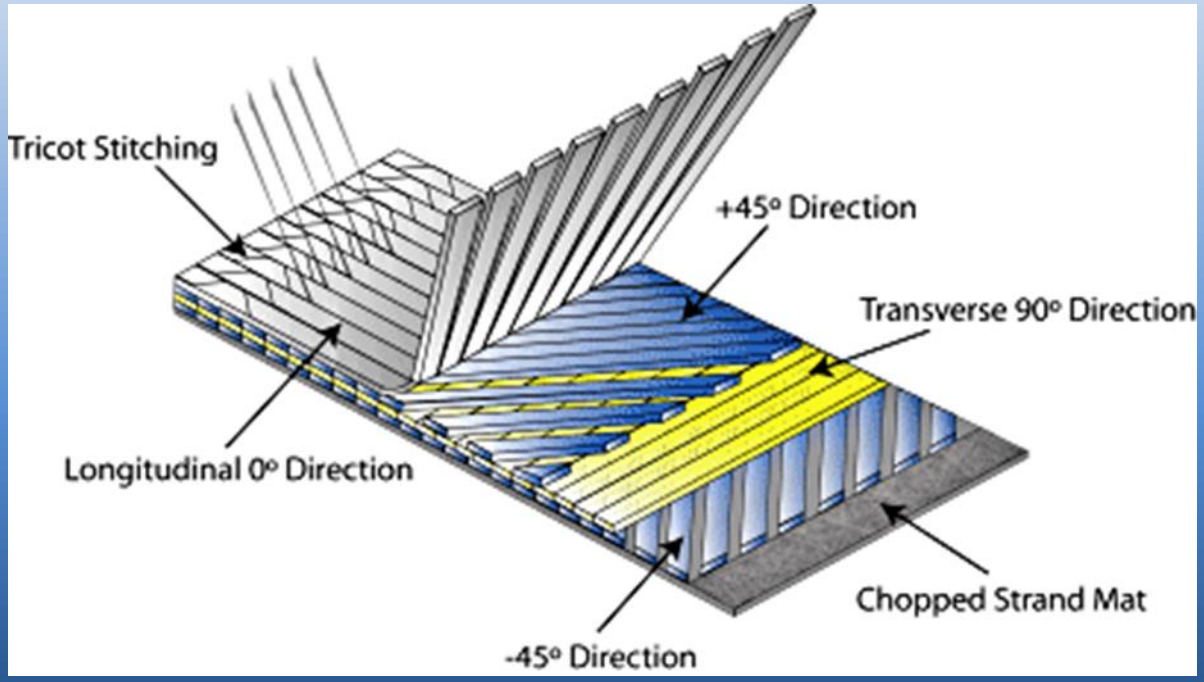


Why choose Non-Crimped Multi-Axial Fabrics?

- Optimized Fiber Properties
- Smoother profile for better surface and less print
- No “crimped” stress on fibers
- Predictable performance
- Greater strength with less resin, therefore overall less weight
- Very high drapeability if desired
- Easier to wet-out
- Multiple architectures
- Less lay-up time
- Different fibers and the ability to hybridize
- Infusion Specific Reinforcements

Vectorply Products

- **Typically available constructions**
  - **Up to 4 plies/layers per one-pass fabric**
  - **Bias angle vary from 30^0 to 90^0: $\pm45^0$, $\pm60^0$, & 90^0 are most common**
  - **Standard constructions**
    - **Unidirectional (0^0 & 90^0), Biaxial ($0^0/90^0$ & $+45^0/-45^0$), Triaxial ($0^0/+45^0/-45^0$ & $+45^0/90^0/-45^0$), & Quadraxial ($0^0/+45^0/90^0/-45^0$)**



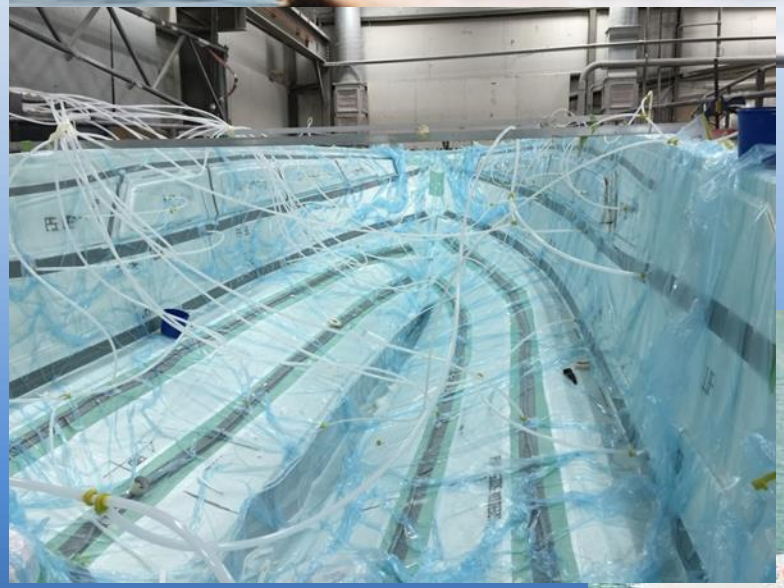
Markets Served – Marine

Viking Yachts – 92C Sportfishing Yacht

Marine Composites

- Boat & yacht hulls, decks, and supporting structure made with composites since late 1930's
  - Historically E-glass/UPR hand laminated using chopper guns & woven roving
  - Last 15 years has shown increased use of closed mold processes (vacuum infusion, LRTM)
    - Lower styrene emissions
    - Better consistency
    - Better mechanical performance
    - Cleaner work environment (employee retention)
  - Recent use of higher modulus reinforcing fibers (carbon)
    - Always used in high end, low volume sailing craft
    - Reduce superstructure weight (lower CG)
    - Reduce overall weight – increased top speed with smaller/cheaper engines
      - Better MPG

Marine Composites



Markets Served – Infrastructure Rehabilitation

Luling (Hale Boggs Memorial) Bridge Deck Rehabilitation in Louisiana (Feb 2016)

Infrastructure Rehabilitation

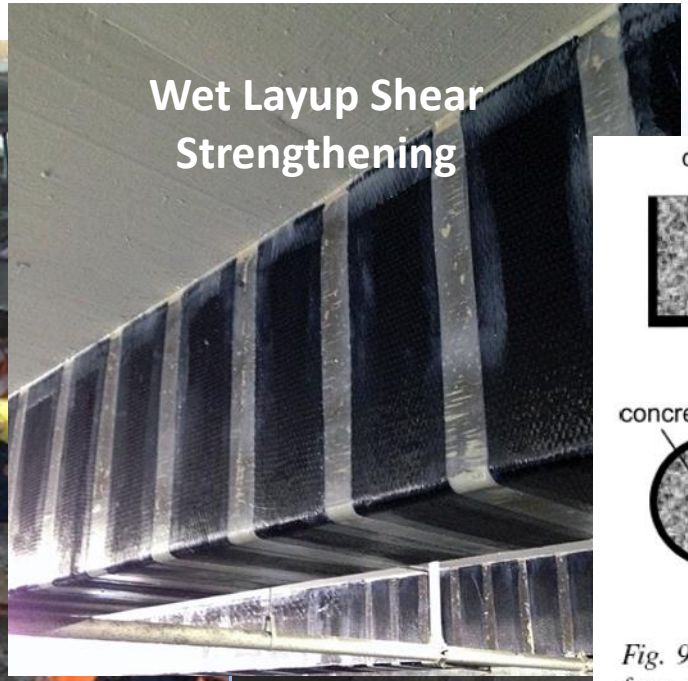
- Externally bonded composites, or "FRP", have been used since the late 1970's for rehabilitation (structural strengthening) of concrete and/or masonry civil structures
- More interest in their use over the last 10 years has prompted development of codes and standards worldwide
  - Japan – Japan Society of Civil Engineers (JSCE), the Japan Concrete Institute (JCI), and the Railway Technical Research Institute (RTRI)
  - Europe - Task Group 9.3 of the International Federation for Structural Concrete (FIB)
  - Canada - The Canadian Standards Association (CSA) and ISIS
  - USA - ICBO AC125, CALTRANS Division of Structures, AASHTO, and American Concrete Institute (ACI) 440 Committee on FRP w/Concrete
    - ACI 440: Material and construction specifications near completion, with the end goal being implementation into design and repair code

Infrastructure Rehabilitation

- Main materials/processes used
  - Hand lamination using unidirectional or biaxial fabrics in epoxy (and cementitious matrix)
    - Mostly carbon fiber based, but also use E-glass and aramid (Kevlar)
    - Similar application and design to oil & gas industry pipe repair
    - Limited use of closed molding (vacuum infusion) to date
  - Application of pultruded rods, bars, and/or plates
    - "Precured" material adhesively bonded to substrate
    - Near surface mounting (NSM) of rods/bars in to substrate
    - Mainly carbon fiber/epoxy based, but some E-glass (rebar)
    - Can be used as prestressing tendons
  - Prepreg systems
    - Moisture cured systems for underwater repairs of piers/marine pilings
  - Stay-in-place forms (SIP's)

Infrastructure Rehabilitation

Wet Layup Column Wrapping



Wet Layup Shear Strengthening

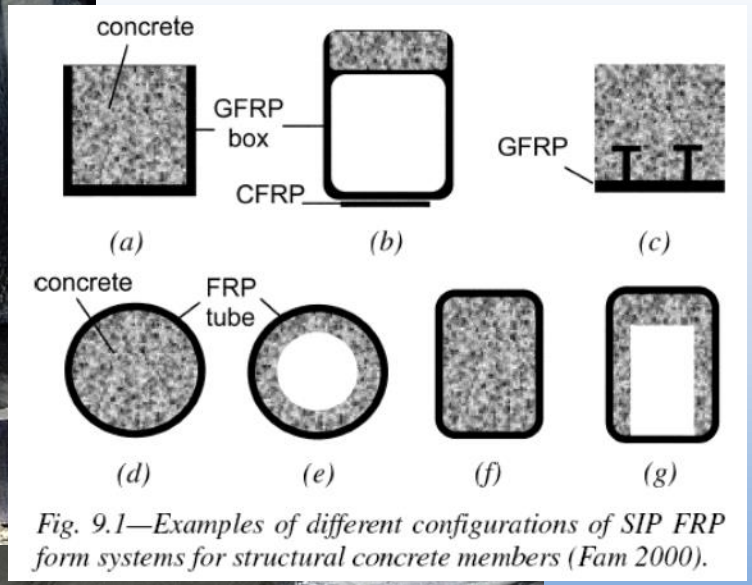


Fig. 9.1—Examples of different configurations of SIP FRP form systems for structural concrete members (Fam 2000).

NSM Flexural Strengthening

Precured Plate Flexural Strengthening

Markets Served – Industrial/Corrosion

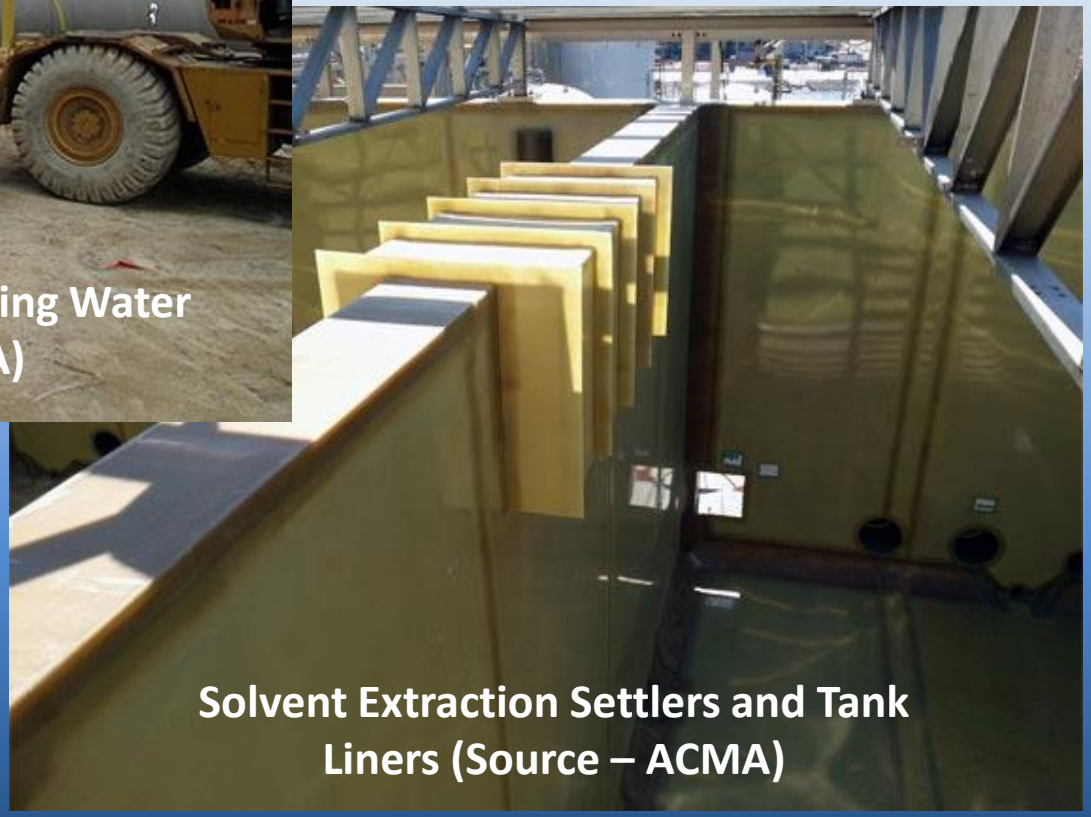
VE/ECR-Glass Box Beams (Top) & JBR Scrubber Deck Panel (Right)

Industrial/Corrosion

- Since the late 1940's, the inherent corrosion resistance of polyester / vinyl ester resin based composites has driven the use of these materials in a wide range of products, such as: tanks, pipes, ducting, chemical plant equipment, wastewater treatment equipment, and many other products (Source – ACMA)
- Resin-rich laminates produced via hand lamination, are steadily being replaced by higher performance, higher fiber content, vacuum infused options
  - Lower resin content can lead to attack of standard E-glass fiber by highly acidic chemicals
  - Lead to development of "ECR-Glass", or Corrosion Resistant E-Glass: Extremely low boron oxide content

Industrial/Corrosion

Large Diameter P-Series Cooling Water Pipe (Source – ACMA)



Solvent Extraction Settlers and Tank Liners (Source – ACMA)

Markets Served – Aerospace/Defense

Bombardier CS100 (Top)
& Cirrus SF50 (Right)

Aerospace/Defense

- Composite aerospace (both military and commercial) applications have led the way in material innovation since the invention of carbon fiber in the late 1960's
- Composite materials have traditionally been relegated to secondary structures (control surfaces, fairings, interiors) due to lack of reliable design data and brittle failure behavior
  - Statistical design criteria called "A-Basis" and B-Basis" values required
  - Adequate compression after impact (CAI) properties are required for primary structures
- Industry shared property databases (AGATE, NCAMP, CMH-17) now allow for more specific design values
- Increased performance prepreg systems now allow for composite material use in primary structure (fuselage, wings, etc.)

Aerospace/Defense

- The reliable autoclave-cured carbon/epoxy prepreg is being threatened due to cost considerations
  - Larger primary structure parts require larger autoclaves
  - Autoclaves are expensive to purchase and maintain
- Most innovation is geared toward out-of-autoclave (OOA) technologies
  - Oven cured OOA prepregs
  - Vacuum infusion techniques (CAPRI, VAP, etc.) using dry fabric preforms and liquid resins
  - All need to provide low void content (< 2%) and high properties akin to current autoclave prepreg systems
- Vacuum infusion processes incorporating pultruded profiles and stitching to produce predictable failure modes
  - Pultruded Rod Stitched Efficient Unitized Structure (PRSEUS) – Boeing/NASA

Markets Served – Automotive

BMW i3 Megacity Vehicle (Left)
Dodge SRT Viper (Bottom)

Automotive

- Low volume (>10,000 ppy) automotive components have been produced for decades
  - SMC/BMC body panels
  - Filament wound drive shafts
  - Low volume supercar chassis (mainly in Europe)
- New CAFE standards are driving use of composites in mid to high volume vehicles requiring shorter cycle times, decreased cost, and low environmental impact
  - Rapid cure epoxy technology
  - Thermoplastic composites: LFRT and continuous fiber
  - Natural fiber composites in non-structural components (headliners)
  - Optimized processes
    - High pressure resin transfer molding (HP-RTM)
    - Low volume SMC
    - All composite filament wound compressed gas cylinders (fuel cell vehicles)

Conclusions

- Composite materials are being used in more applications than ever before
- Greater design knowledge, process flexibility, material availability, and need for lightweight/high performance is driving use
- Work is still being done to address composite materials weaknesses
  - Relatively slow cycle times
  - Interlaminar properties – nano-scale strengthening
  - High costs
  - Property variability

VECTORPLY®
PERFORMANCE COMPOSITE REINFORCEMENTS

Home | About Vectorply | Vectorlam | Products | Markets | Contact

For more information about Vectorply Corporation visit our website, VECTORPLY.COM today!