Use of pultruded foam panels in refrigerated trucks – New MP technology. (Patent pending)

Summary.
Mastercore has invented an efficient and cost-effective process for creating a composite material that has very significant performance advantages over competing materials and constructions in use today across a wide variety of commercial applications. Its new composite sandwich material is superior to steel, wood, aluminum, vinyl or combinations thereof, and is adaptable to hundreds of applications within the transportation, construction, defense, and marine industries. This new composite material features:

1. **high impact strength**
2. **high toughness**
3. **high stiffness-to-weight ratio**
4. **high fatigue life**
5. **high thermal stability**
6. **low dielectric constant**,
7. **low thermal conductivity**.

This new composite material, called "MP" (Mastercore Panel), is a sandwich construction consisting of 1) an outer shell of a polyurethane-impregnated glass-fiber, carbon-fiber, or blended glass- fiber/carbon-fiber matrix, and 2) an inner core of a special CFC-free structural foam material that bonds to the interior of the profile walls. The MP composite can be produced in any **continuous lineal shaped** profile, in any length, and in widths up to 4 feet wide (although wider dimensions could also be produced).
An MP lineal profile shape can be designed with thin walls for sharp corners or with intricately rounded profiles, with multiple radii. Or, the MP profile can be designed with a thicker shell for greater impact resistance, rigidity, and shear strength. The foam core density can be adjusted for optimum weight/performance characteristics.

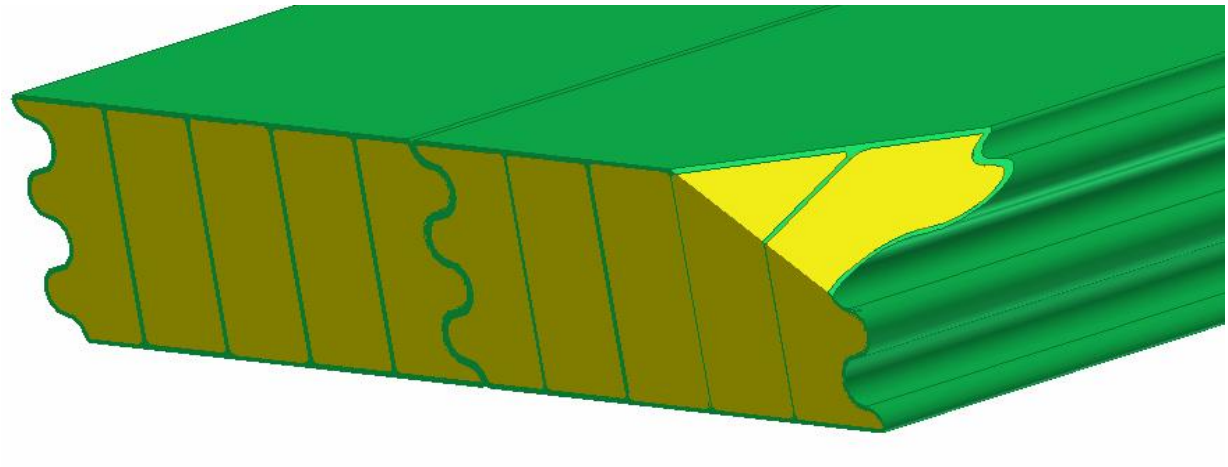
1. Mastercore process.

The relatively high cost of a composite-sandwich construction has long been a barrier to use in many applications; however Mastercore's singular process breakthrough makes the advantages of composite products available for an unlimited range of applications. The MP manufacturing process integrates the use of low-density, closed-cell foam with glass-fiber and/or carbon-fiber skins within a three-dimensional architecture that utilizes interior walls, webs, or struts to achieve the desired strength, stiffness, and weight requirements of any particular lineal profile or panel.
The MP process eliminates **VOC emissions**, and **does not violate any other environmental** regulations that cover harmful emissions, materials or residue.
In essence, this is the ideal engineering material for a multitude of applications, as the shell's wall thickness, the core's foam density, and the interior geometry of the supporting webs are all adjustable in order to obtain a part with the optimal strength and weight characteristics desired for your application or for your customer.

2. Mastercore Technology (MP).

In order to demonstrate the MP technology, we will use a description of specific product – a proposed new floor – wall / roof and truck door construction.
The MP composite structure features a strong and extremely durable external skin, with strong and stiff webs attached to the internal face of that skin, as shown in pictures below.

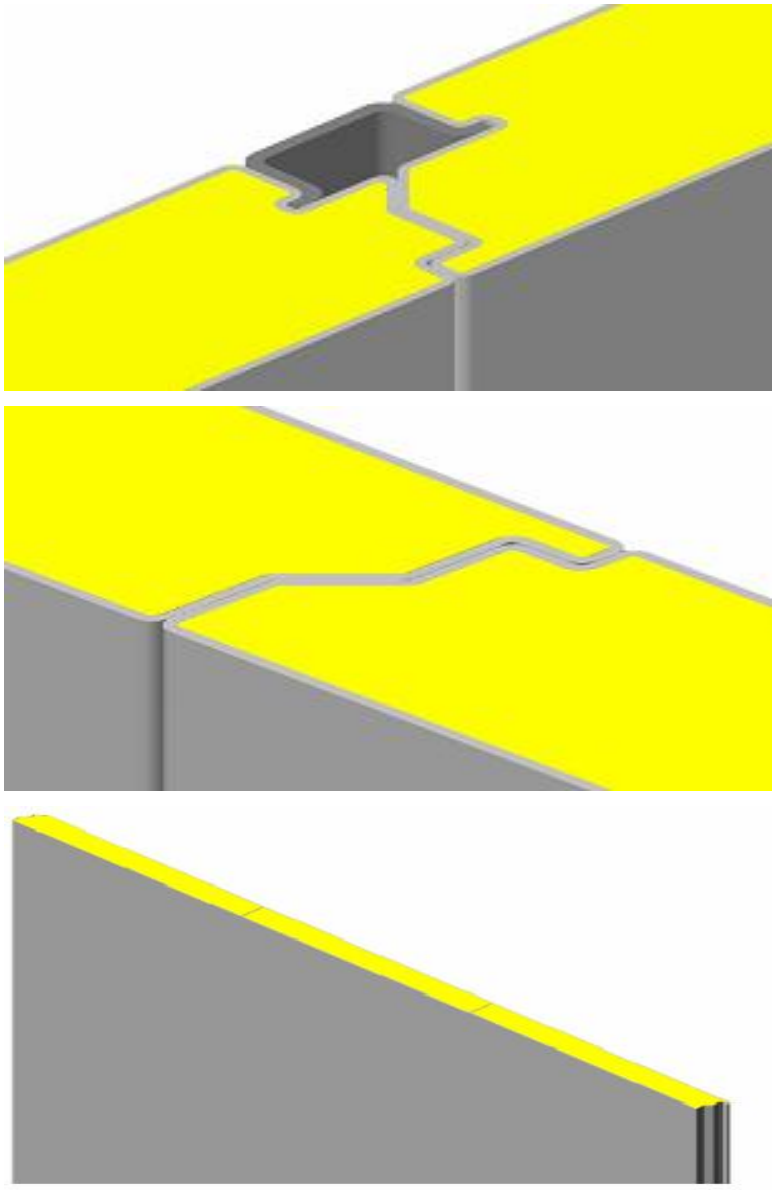
A. Floor system



Despite its relative lightness, the composite-mat fiber skin and interior web designs of this profile provide significant compressive strength, tensile strength, and shear stiffness in any direction. All characteristics are well in excess of strengths needed for a truck floor.

B. Wall / Roof system.

The flagship product is a wall panel system **(MP)** for both straight trucks and van trailers. The **(MP)** are constructed on a unique manufacturing line that utilizes the foam laminating equipment to pultrude the reinforced composite skins. These panels will replace the wood, steel and sheet metal currently used to build truck bodies and trailers. The systems **(MP)** will make it easier to build the truck bodies and trailers and to replace damaged panels in the future. By eliminating steel and sheet metal the **weight of the truck will be reduced, thus increasing gas mileage.**



C. Door System

These are some examples of utilizing a web or sandwich construction with an outer fiberglass skin and an inner foam core. Unlimited design flexibility can be achieved through the selection of the cross-section dimensions, interior supporting wall flanges, wall thickness, fiber matrix material, and foam density characteristics.

Combining low-cost glass roving, mats or veils to produce skins, along with low-cost foam filling, creates the most economical construction material presently available for many types of applications. Yet, the MP profile and panel sandwich production methods are also applicable to higher-property forms, making use of a variety of structural fibers (including carbon fibers). High-performance foams and fibers could be used in products that meet the much higher performance requirements of aerospace structures.

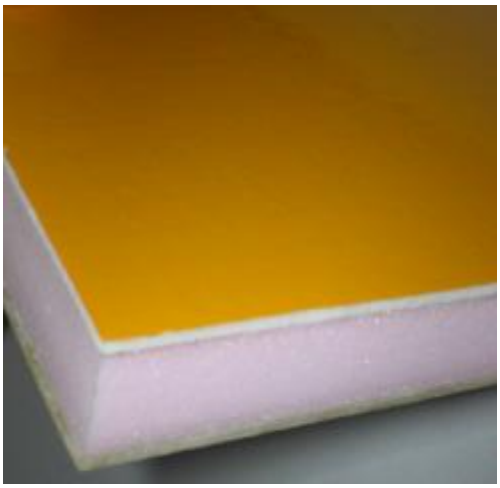
Initial potential applications include, but are not limited to: truck wall and roof panels, truck floors, truck doors (swing and roll-up), mobile home and manufactured housing wall, floor and roof panels; temporary military shelters featuring crated wall, floor, and roofing panel systems; temporary shelter systems for rapid disaster relief response. Also: decking, siding, commercial and residential roofing, fencing, boat docks, ocean freight containers,

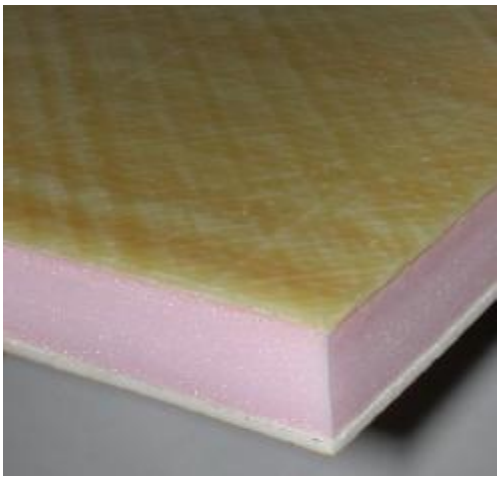
air freight containers, foundational wall systems, floor joists, flood control and erosion control barriers, storage facilities, highway sound barriers, racquetball and squash court panels, etc. The applications are limited only by one's creative imagination. Simply stated, MP is stronger, lighter, more durable, and more cost effective than any other known material presently on the market. The life span of MP panels will be much longer than for any competing material And, in all of the above applications, the MP panel system is more easily and economically repairable (in case of need) than any competing construction system. .

3. The Process

Once a desired profile shape has been designed, a relatively inexpensive die is made to form it. The profile's outer shell is produced from a polyurethane-impregnated glass and/or carbon fiber matrix that is "pultruded", or pulled through a series of shaping dies to form a hollow profile of any shape. The shell's wall thickness can range from .025" to ½" (inch). While this shell is hardening through the heated dies, closed cell foam (of any desired density) is injected into the interior hollow portions of the profile. The profile surface may be gel coated during the curing process for a superior finish in any desired color (like a boat hull).

This streamlined process enables the MP composite profile to emerge from the die in a finished state, simply to be cut to any length with a flying diamond-tipped saw-blade, for immediate packaging and shipping.

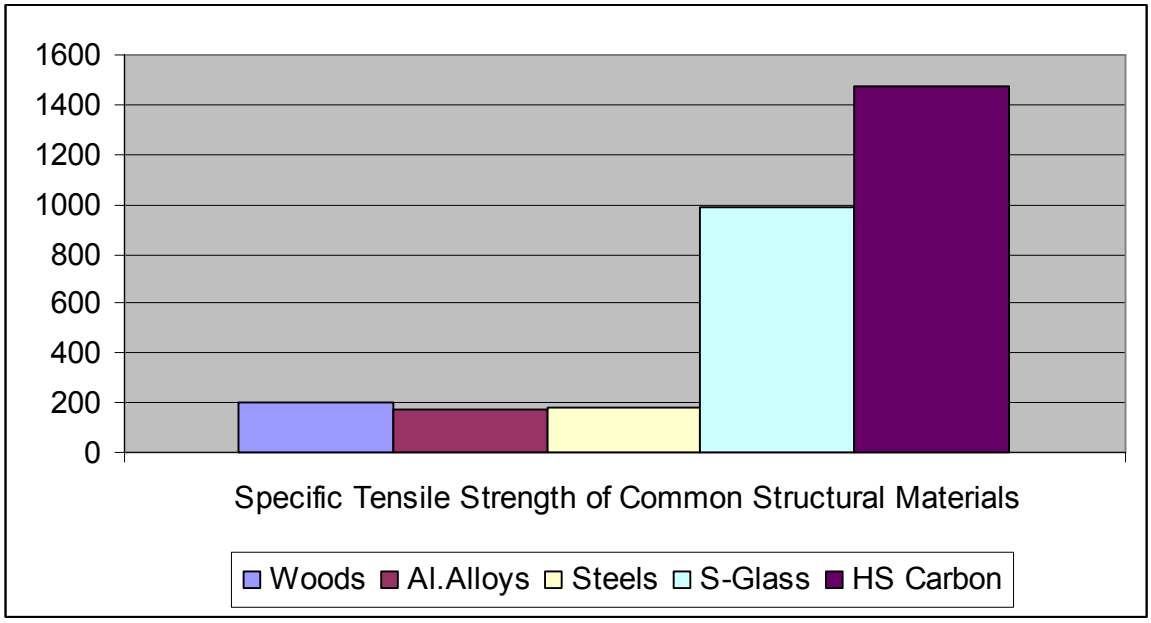




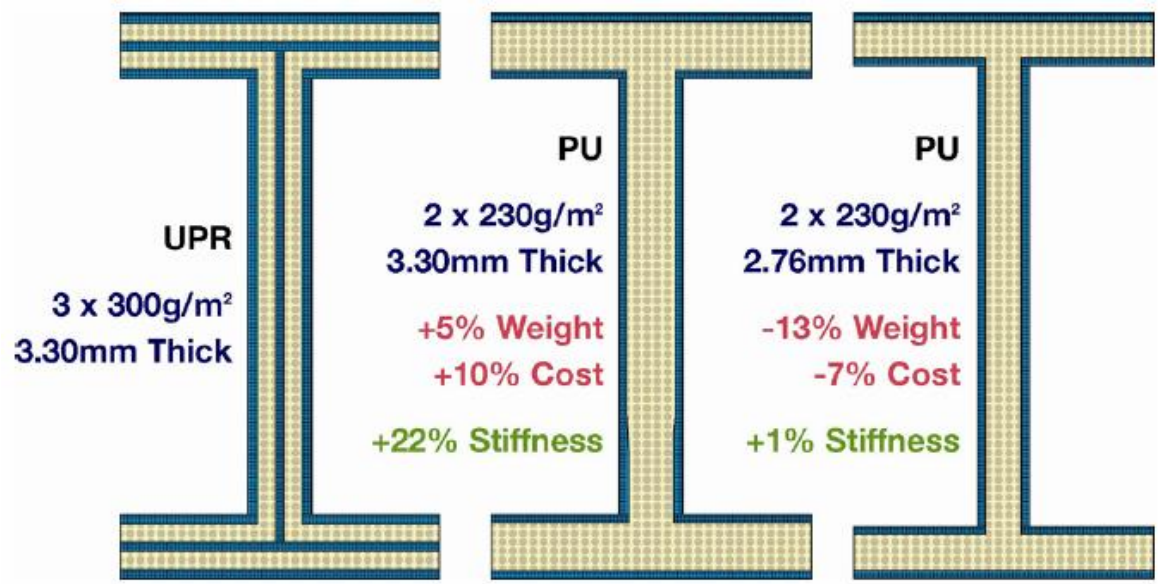
Mastercore's process patent application is currently pending and various other specific application patents are either pending or already granted. The MP process will be thoroughly patent protected worldwide.

4. Comparison with Other Structural Materials

There are many materials and geometry designs, used to accomplish a very large range of mechanical properties that can be produced with Mastercore's technology. Even when considering one fiber type on its own, the composite properties can vary by a factor of 10 within the wide range of fiber content and orientations that can be easily designed and achieved via the Mastercore Panel technology. (Optimum profiles and materials will be designed using the Mastercore propriety software design and engineering files.)
The strength & stiffness to weight ratio of composite materials can best be illustrated by the following graph (Mpa):



There is proven advantages of using composites from a strength, stiffness, and weight standpoint. The range of properties that MP technology can accomplished is quite broad, and only depends on the designer's choices of fiber material, wall thickness, foam density, etc. The primary advantage of composites is that high strength and stiffness can be achieved with relatively low densities, and therefore, lower weight. (Mastercore has developed software programs that will give the designer total control of all composite forms and features.)



Comparison of Cost, Weight and Stiffness of Unsaturated Polyester and Polyurethane I-Beams with Various Glass Lay-Ups

Lower weight is of primary importance in applications that involve movement, such as cars, trucks, trains and aircraft, since lighter structures in such applications play a significant part in making these applications more efficient from a fuel consumption standpoint.

Comparison to WOOD:

Unlike wood, **MP does not swell, rot or decay** from exposure to moisture, water, or chemicals. It does **not split, crack, splinter, or warp**. **No hazardous coatings** are needed to provide protection against insects or vermin. It is estimated that an MP profile will last up to 400 years in any exterior application, no-matter how humid, hot or cold the environment is—from Arctic cold to blazing hot desert to misty saltwater coastlines.
Another advantage is that the MP profiles or panels can be bonded together. This procedure forms **strong structures** that do not come apart even in damp conditions, thus solving a structural problem that has plagued wood or plywood panel construction.

The MP has a far **greater strength to weight ratio** than does a wood profile of the same size and shape. It will not warp or delaminate like plywood sheets. It will not attract mold and mildew due to moisture absorption. It will not rot, crack, or split due to continuous exposure to temperature extremes, moisture penetration, or multiple freezing cycles.
The **gel coat finish** on the MP has a far longer life than typical paints and stains applied to wood.
Wood is easy to fabricate with staples, screws, nails, and/or glue**. MP profiles, with high-density foam, fasten together just as easily as wood.** The MP composite sandwich holds staples and screws securely because of the strength of the outer shell wall and the tight cell

structure of the foam interior (no splitting, as is often seen in wood). MP parts can also be glued together or bonded between joints where necessary.

Comparison to STEEL

Unlike steel, **MP is highly resistant to corrosion and oxidation.**
The MP shell alone is many times lighter than steel, and by adding the foam core filling, you get the **equivalent strength of steel** with much less weight but many more years of life**.**
As for impact resistance, steel will permanently deform upon impact. But the glass mat and foam core in pultruded MP parts distribute the impact load to prevent surface damage. As a result, **MP does not permanently deform under impact**. However, if by some means or accident an MP form is damaged, it can be much more easily repaired (generally in place) than an equivalent form made of steel.
MP has a **low thermal conductivity** and is the **ideal refrigerator truck** . A ½" thick piece of MP composite with a .050" skin would have a **thermal conductivity factor of 0.26**(BTU/SF/HR/F^{o}/IN).
Fabrication of steel requires welding torches. MP parts fasten together as easily as wood, with mechanical or adhesive bonding.
Stamping shapes from steel coil is labor and equipment intensive, with relatively high costs of modification and slow response to changes. Steel fabrication **utility costs** are very high. The MP process makes the creation of high performance materials both inexpensive and fast, in practically any continuous shape.

Comparison to ALUMINUM

MP has **tremendous thermal advantages** over aluminum extrusions. The MP shell alone is **500 times less conductive than aluminum.**
Aluminum and aluminum-clad truck wall and roof systems have suffered from poor thermal performance for several decades. MP foam parts would greatly add to the thermal performance of panels. Aluminum also suffers from a relatively high coefficient of thermal expansion. MP's very low thermal coefficient of expansion is also making the MP panel an ideal system for refrigeration wall system.
Most of present trucks are constructed using aluminum cladding. They are subject to permanent denting from impacts. The MP panel, on the other hand is dent resistant, is far lighter, stronger, more thermally efficient, far easier to assemble. The MP panel requires no rivets for assembly nor does it require exterior or interior bracing. This construction feature allows exterior advertising on the truck walls and doors to be much better looking and longer lasting.

Comparison to PVC

MP is cost competitive with PVC, but is environmentally friendly. MP is made from glass fiber (sand as the raw material), polyurethane (soy bean based product), and recycled plastic material (for the foam component). MP forms and panels are inert; there is no environmentally unfriendly material used in composition.

5. Mastercore's Computer Simulation for Engineered Composite Profiles.

Mastercore is the leader in **Computer-Based Simulation and Product Optimization for Composite Materials.** With its proprietary programming, Mastercore can immediately analyze which fiber matrix is optimal and immediately adjust the thickness of the proposed profile's walls, the geometry of the interior supporting webs (if any are needed), and the density of the foam in order to achieve the desired balance between weight, cost, and strength in any profile, tubular, or panel design.

Mastercore's Computer Simulation has ability to analyze and calculate every aspect of any design of any MP linear profile, tube, or panel configuration. This software calculates automatically all parameters in any specific part design.
There are many standards that we take into account during the computer design process. Below we present just a few of the many parameters each specific application requires:

a. Product's expected weight
b. Foam quality and density
c. Wall thickness
d. Internal web's thickness and geometry
e. Thermal performance
f. Surface finish

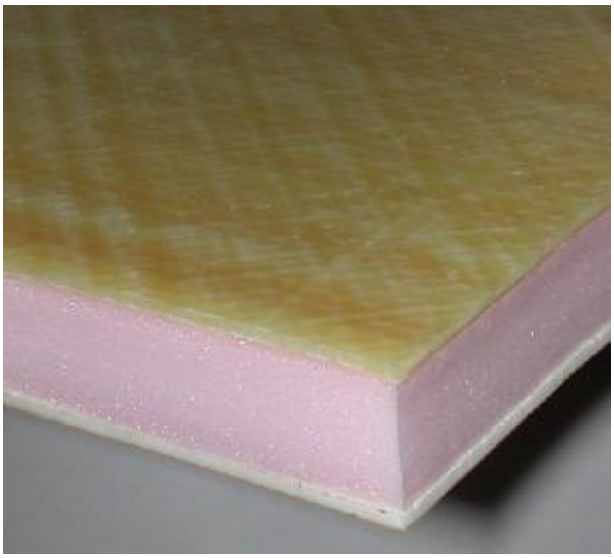
After computer modeling and simulation is completed, we build a prototype to conduct experimental measurements to evaluate and crosscheck our mathematical models. When ever possible, we conduct comparisons of the MP product with similar products presently used in the industry. The MP Composite engineering process, then, allows a new, unique material to be produced for a specific application with all of the properties specifically designed and calculated in advance. This approach opens up the possibility of multiple application patent protection and the building of significant intellectual property assets.

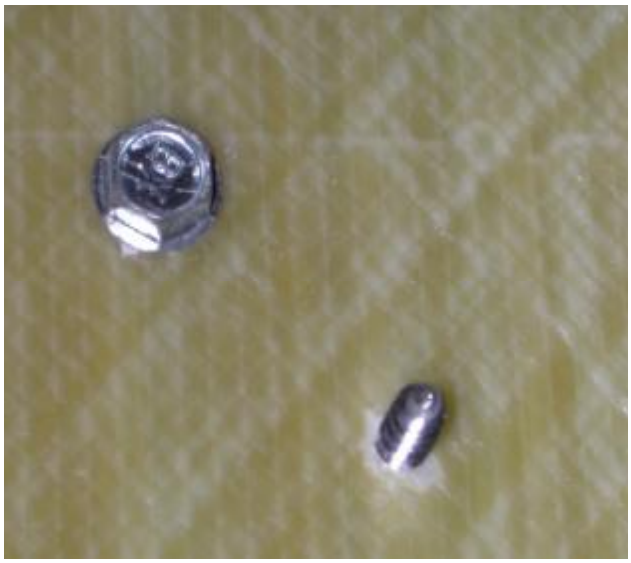
6. Prototype and production ability in short time cycle

Because of Mastercore's unique production process**, a low-cost production die can serve as both a prototyping die and a production die.** The profile die can be ordered and received **within a few days of the initial profile design**, and for a fraction of the normal die costs associated with typical fiberglass pultrusions. As a result, changes or improvements to a particular profile can be achieved rapidly and cost-effectively, making speed to market a significant competitive advantage

In applications of the MP technology, it is also important to evaluate damage resistance when the product requires the use of fasteners. In our process of computer design we will evaluate all bonding and fastening requirements to ensure product functioning and performance.

The polyurethane pultrusion is the most durable composite material and can accommodate insertion of screws without splitting, as illustrated below.





Generally, by utilizing an MP composite profile, one can expect a 30-50% reduction of raw material costs, while ending up with a product that is lighter and stronger and less thermally conductive than its predecessor profiles.
Thus, the MP Composite is greatly superior to other materials because of its unique sandwich construction and low-cost singular process of production and assembly. The combination of an outer glass-fiber, carbon-fiber, or blended glass/carbon skin, with an expanding and rapidly curing closed-cell foam core that bonds to the interior surfaces of the profile, makes the product incredibly strong and light. The **foam core increases the strength of the part by a factor of some 40 times** over a similar pultrusion profile without the foam support. In essence, the foam core does the work of multiple legs and thicker walls—**but at a fraction of the cost and weight.** Using the idea of creating a **beehive construction within the foam itself,** using nothing more than harmless carbon dioxide, **proved to be the key** (patent protected) for all the performance, weight, and strength advantages of the MP composite substrate. And at the same time, such a construct adds thermal performance and acoustical advantages over other competing substrates.

In summary, MP composite technology provides the following advantages:

The new material is **stronger and more durable than any other material** presently available in our target markets. The life span of the new material is much longer than that of competing materials.
The MP composite can be produced **in any length in a continuous process** and with any geometry in a variety of colors and finishes. The MP composite parts **can be fused together** forming strong edges that do not come apart.
MP Composites can be manufactured **using high-rate automated production equipment**, with a low labor component, and a continuous 3-shift operation, with adequate quality control and maintenance regimens designed into the process.
The MP Composites process literally gives birth to a new material composites industry for the 21st century, one that is cost competitive with any other structural material currently in the marketplace, one that can provide performance characteristics heretofore unachievable, and one that can revitalize whole sectors of the ailing manufacturing industry.

Mastercore Systems, Ltd.

By Andrew Rekret.
Amsterdam – October 19, 2005