Robert Eller Associates, Inc.

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

LIGHTWEIGHT COMPOSITES AND NATURAL FIBERS IN AUTO INTERIORS

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PREPARED FOR:
PLASTICS IN AUTO INTERIORS
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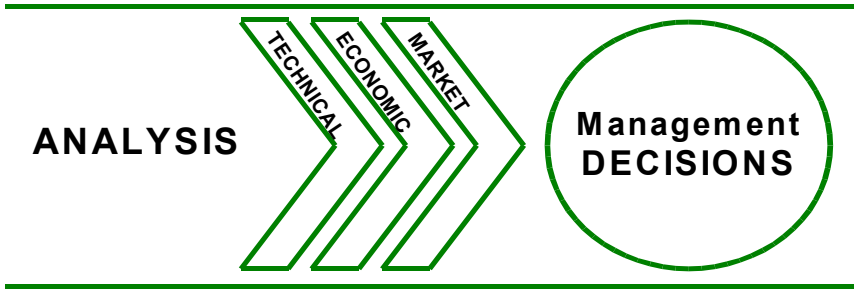
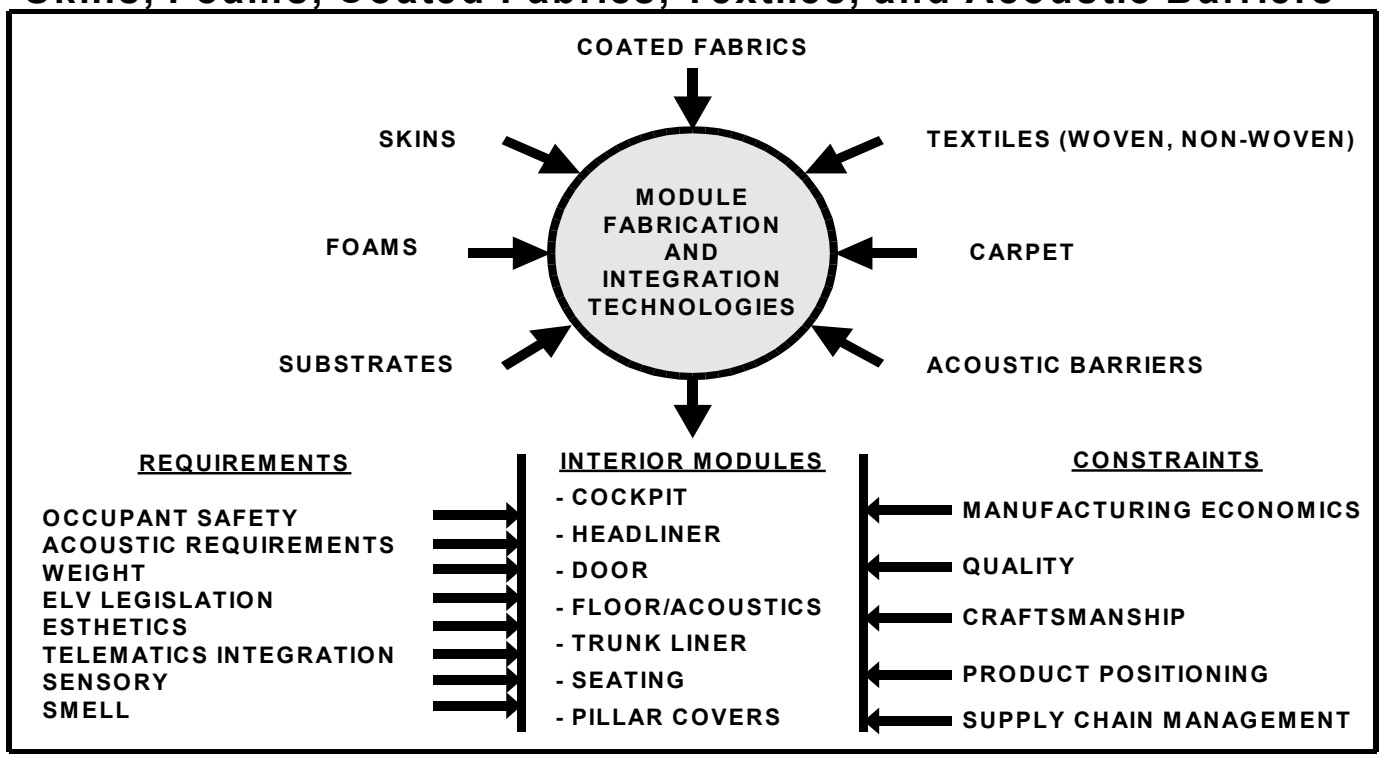
HIGHLIGHTS

- **AUTOMOTIVE ECONOMICS/EFFECTS ON COMPOSITES INDUSTRY STRUCTURE**
- **PERFORMANCE EFFECTS ON MKT POTENTIAL**
- **LIGHTWEIGHT COMPOSITES MARKET POSITION**
- **COMPETITION WITH NON-COMPOSITES**
- **INTRA-COMPOSITE COMPETITION**
- **INDUSTRY STRUCTURE SHIFTS**



Automotive Interior Soft Trim:

Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers



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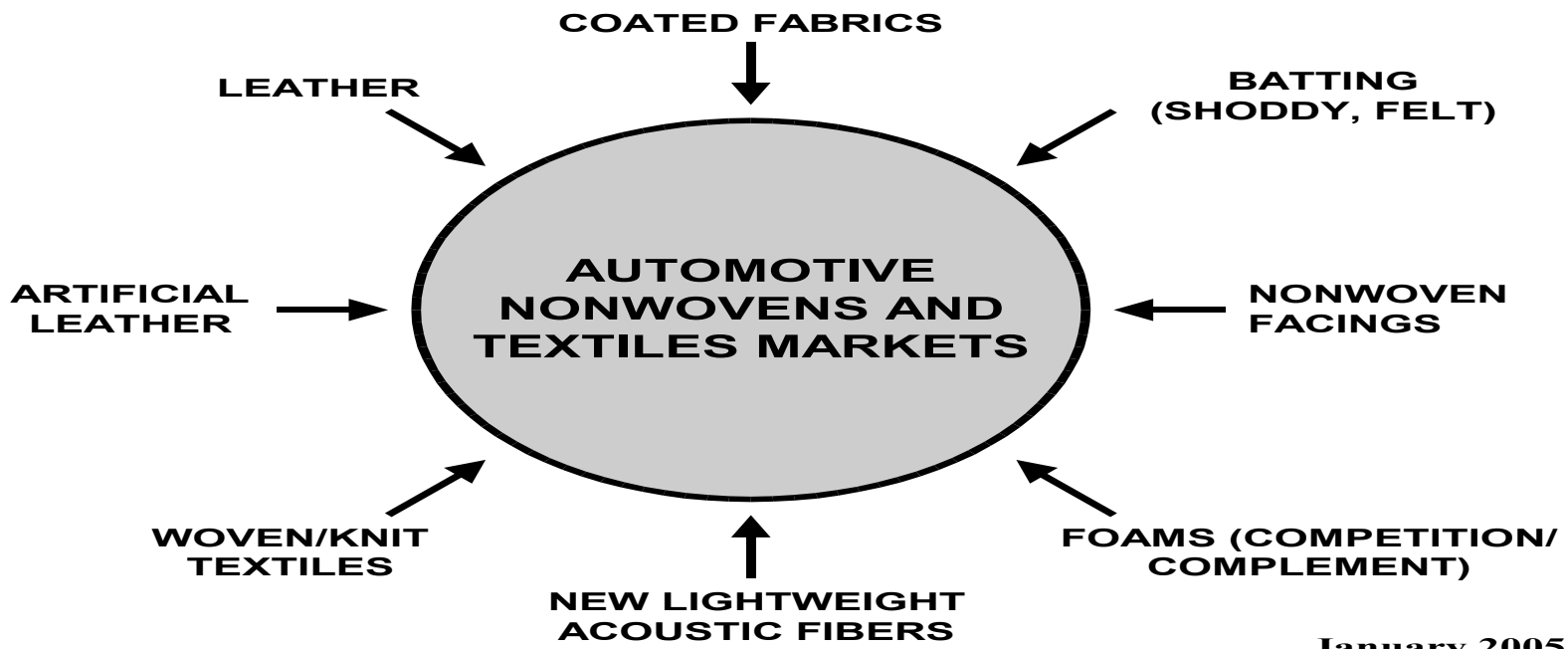
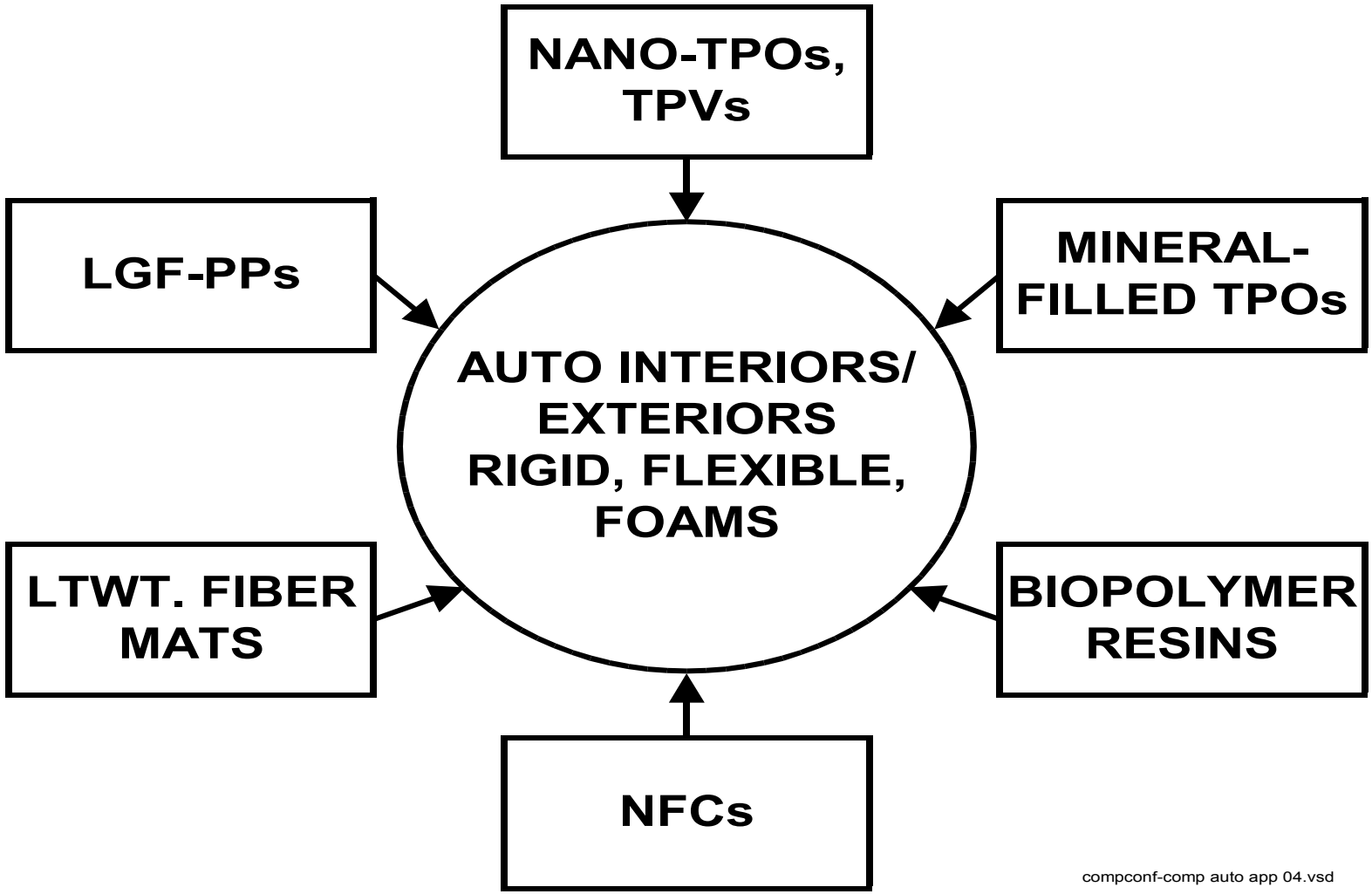
Prospectus for a Multiclient Study
Completed December 2004

Opportunities for Advanced Technology Nonwovens for Automotive Surface and Construction Applications in N. America and Europe



January 2005

COMPOSITES COMPETITION FOR AUTOMOTIVE APPLICATIONS



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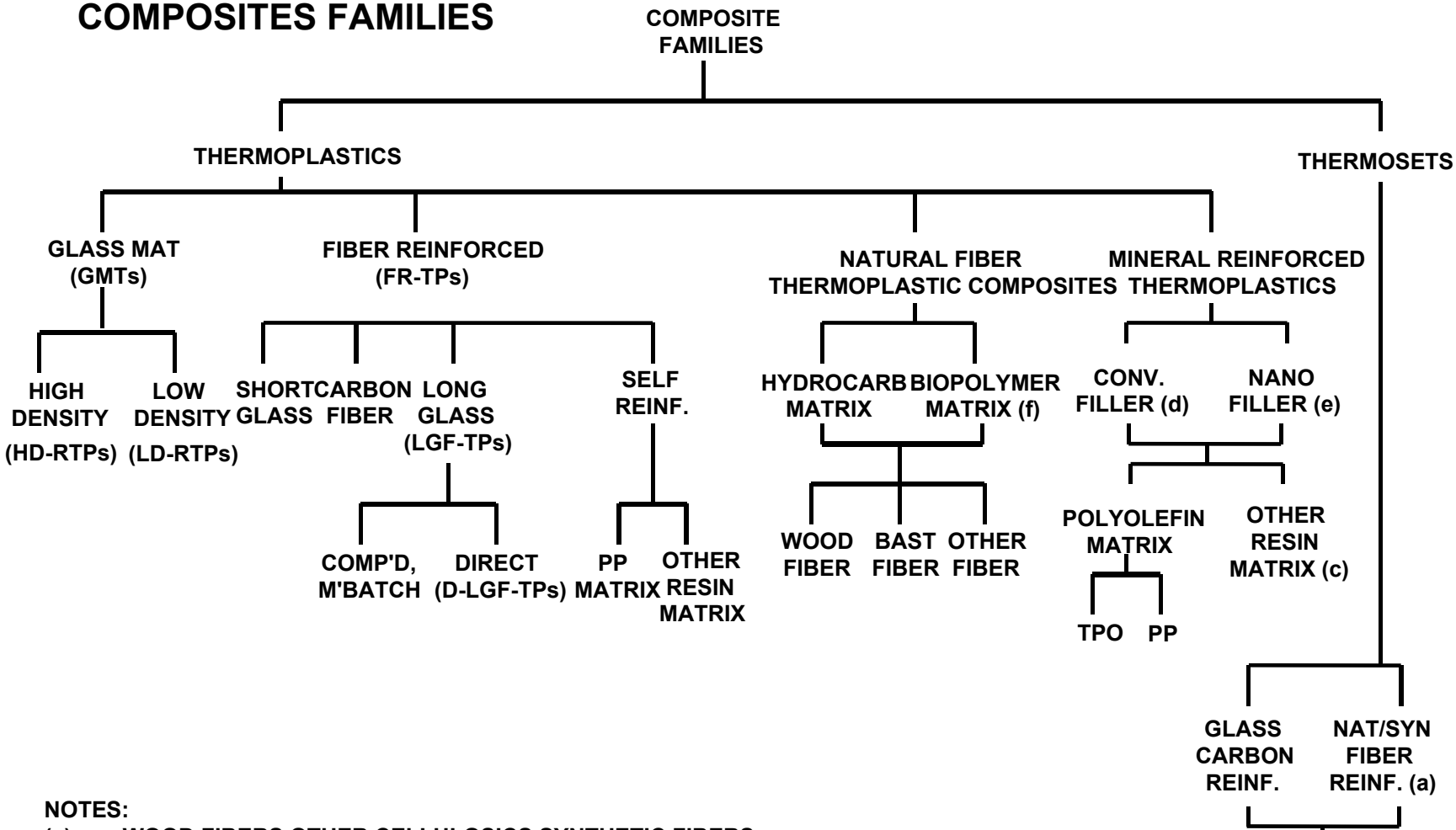
OPERATING HYPOTHESES

- **COMPOSITE TARGET CLASSES INCLUDE:**
  - **STRUCTURAL (XC BEAM, FLOOR, ROOF)**
  - **SEMI-STRUCTURAL (FLR MODULE, HL)**
  - **MECHANICAL**
  - **NON-STRUCTURAL (SEAT BACKS, DOOR TRIM)**
- **INTER-MATERIAL AND INTER-PROCESS COMPETITION**
- **ENERGY ABSORPTION IS A DRIVER**
- **INTEGRATION OF EA AND ACOUSTICS**
- **THERMOPLASTICS WHERE POSSIBLE**
- **WEIGHT SAVINGS INCENTIVES INCREASE**
- **SPACE SAVINGS ARE VALUED**

OPERATING HYPOTHESES (CONT'D)

- **NATURAL FIBERS CAN/WILL COMPETE**
- **NATURAL FIBER CHALLENGE TO GLASS FIBERS**
- **GROWTH OF "TALL CARS": FLR MODULE GROWTH**
- **FLOOR MODULES: LARGER, MORE COMPLEX**
- **EUROPEAN FEM GROWTH: STIMULATE COMPOSITES**
- **COMPOSITES SUPPLY CHAIN CONSOLIDATION**
- **BIOMATERIALS ENTERING: FIBERS/MATRICES**
- **NANO-COMPOSITE TECHNOLOGY: N. AMERICA MORE ADVANCED**

COMPOSITES FAMILIES



NOTES:
(a) e.g. WOOD FIBERS,OTHER CELLULOSICS,SYNTHETIC FIBERS
(b) e.g. COMPRESSION MOLDED WOOD/PHENOLICS OR COMPRESSION MOLDED REGENERATED FIBER MATS
(c) e.gENGINEERING THERMOPLASTIC (ETPs), TYPICALLY NYLONS
(d) e.g. CLAY, TALC, CALCIUM CARBONATE,SILICA, MICA, WOLLASTONITE
(e) e.g. CLAY (MOST COMMON), TALC (STARTING), SILICA, CARBON NANOTUBES
(f) e.g. PLA, PHA, OTHERS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

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AUTO INDUSTRY EFFECTS

- **SLOW EMERGENCE FROM RECESSION?**
- **TIER 1 PROFITABILITY SQUEEZE**
- **GLOBAL PARTS SOURCING (CHINA)**
- **TIER 1 CONSOLIDATION: INCREASE PURCHASE POWER**
- **DOMESTIC OEM MKT SHARE LOSS**
- **HIGH VOLUME PLATFORM GROWTH**

COMPOSITES SUPPLY CHAIN SHIFT

- **BROADENED COMPOUNDER PROD. LINES**
- **FIBER/NANO-CONCENTRATES STARTING**
- **DIRECT COMPOUNDING GROWING**
- **NATURAL FIBERS, BIOPOLYMERS, NANO COMPETING**
- **MODULARIZATION:INTEGRATION VIA COMPOSITES**
- **COMPOSITES ENTERING NEW VEHICLE MODULES/FUNCTIONS**

INTRA-COMPOSITE COMPETITION

- **LD-RTPs VS. HD-RTPs: SEMI-STRUCTURAL**
- **NANO VS. CONVENTIONAL MINERAL FILLERS**
- **NANO VS. LGF-PPs**
- **NFCs VS. GF-TPs**

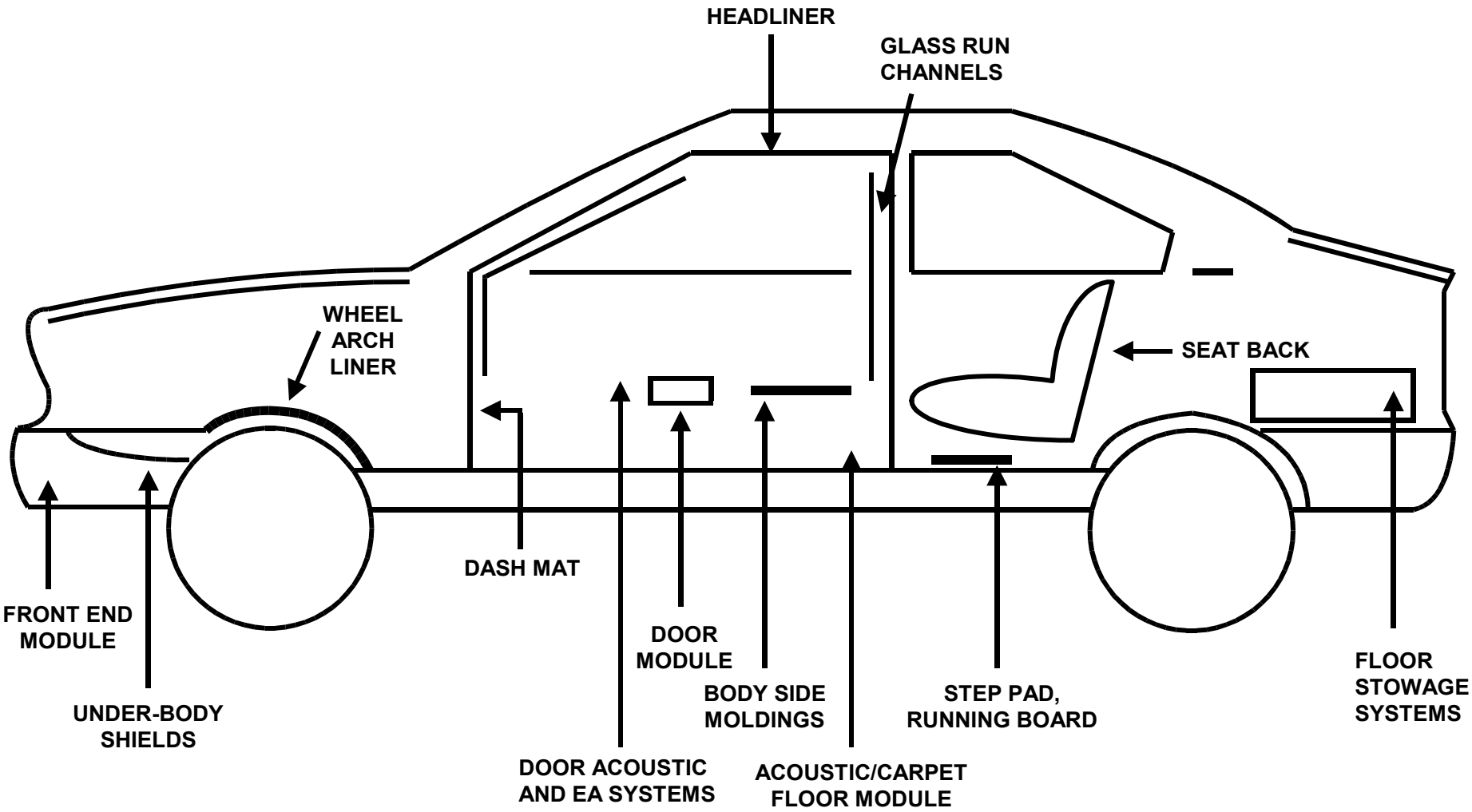
AUTO COMPOSITES INDUSTRY STRUCTURE SHIFTS

- HEAVY GMT SUPPLIERS ENTER LT WT GMT
- GLASS FIBER SUPPLIERS ENTER LGF-TP COMPOSITE PRODUCTION
- COMPOUNDERS ENTER NANO-COMPOSITE AND LGF-TP CONCENTRATES
- DIRECT COMPOUNDING OF LGF-TPs BY:
  - CUSTOM AUTO MOLDERS
  - BACK INTEGRATED TIER 1s
- ENTRY OF NATURAL FIBER PRODUCERS (SOME VIA BACK INTEGRATION BY AUTO OEMs AND TIER 1s)
- EMERGENCE OF BIOPOLYMER SUPPLIERS

COMPOSITES VS. OTHER CLASSES

- **LD-RTPs IN WHEEL ARCH LINERS**
- **LD-RTPs VS. FOAM/SKIN LAMINATES (FLOOR)**
- **LD-RTPs VS. PU, PP FOAMS (H-LINER)**
- **NANO IN FUEL TANKS, SYSTEMS**
- **NANO VS. PVC: (BODY SIDE MOLDINGS)**
- **LD-GMTs AND LGF-TPs: NO COMPETITION**

COMPOSITES TARGETS



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

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LD-GMT THERMOPLASTICS (CONT'D)

- **FMVSS 201**
- **INTEGRATION OF FOAM/ENERGY ABSORBING ELEMENTS INTO SUPPORT LAYER**
- **COMPETES W/ FOAM CORE SOLUTIONS**
- **REQUIRES ACOUSTIC PERFORMANCE**
- **INTEGRATES TEXTILES**
- **VARIETY OF TRIM OPTIONS**
- **HIGH PRIORITY ON SPACE CONSERVATION**
- **VALUE ADDED POTENTIAL**

LOW DENSITY GLASS MAT THERMOPLASTICS (LD-GMT)

- **GENERATION 1 HIGH DENSITY GMTs DECLINING**
- **LD-GMTs IN GROWTH STAGES (DOOR TRIM, INSTRUMENT PANEL, HEADLINER, FLOOR)**
- **CHALLENGE TO INJECTION MOLDING IN INSTRUMENT PANEL & DOOR TRIM HARDWARE MODULE**
- **NATURAL FIBERS ENTERING**
- **INCREASED NUMBER OF SUPPLIERS**

INTRA-COMPOSITE COMPETITION

APPLICATIONS	THERMOPLASTIC COMPOSITE CANDIDATES							
	LD-RTP	HD-GMT	SGF-TP	LGF-TP	HC-NFC	MIN-TP	NANO-TP	OTHER (a)
ACOUSTIC BARRIERS	X							X
BODY SIDE MOLDINGS				X		X	X	X
BUMPER FASCIA						X	X	X
DOOR TRIM PANELS					X	X	X?	X
DOOR MODULES	X	X?	X	X				
ELEC. CONNECTORS			X				X	X
FLOOR MODULES	X	X			X			X
FEMs		X(b)		X				X
FUEL LINES							X	X
FUEL TANKS							X	X
HEADLINER	X							X
IN MOLD DECORATION							X	X

INTRA-COMPETITION FOR AUTOMOTIVE APPLICATIONS (CONT'D)

APPLICATIONS	THERMOPLASTIC COMPOSITE CANDIDATES							
	LD-RTP	HD-GMT	SGF-TP	LGF-TP	HC-NFC	MIN-TP	NANO-TP	OTHER (a)
INTERIOR SKINS								X
IP SUBSTRATES				X	X	X		X
MECHANICAL COMPONENTS			X			X	X?	X
ROCKER PANELS						X	X	X
RUNNING BOARDS				X			X	X
STEP PADS				X			X	X
WHEEL ARCH LINER	X					X		X

NOTES:

(a) OTHER INCLUDES NON-COMPOSITE COMPETITION FROM:

- **FOAMS**
- **NONWOVENS**
- **FOAM/SKIN LAMINATES**
- **THERMOSETS (PU, PET)**
- **-UNFILLED POLYMERS (PRIMARILY ETPs, PVC)**
- **-METAL/PLASTIC HYBRIDS**
- **-REGENERATED FIBER MATS (SHODDY)**

(b) HD-GMTs HAVE LOST SHARE IN FEMs

COMPARISON OF LD-GMTs AND LGF-PPs

PARAMETER	LGF-TP	LD-GMT
DENSITY, GSM		LOWER, 700-2000 (a)
TOOLING COST		LOWER (b)
TYPICAL PROCESS	INJECTION, COMPRESSION	COMPRESSION, THERMOFORMING
TYPICAL GLASS CONCENTRATION, %	40, 32	40-55%
DIRECT/COMPOUND/ FABRICATION POSSIBLE	YES, COMMON	YES, POSSIBLE; NOT COMMONLY USED
TYPICAL PART	COMPLEX	SIMPLE
PART SIZE	SMALL	LARGE
PART THICKNESS	THICKER	THINNER

COMPARISON OF LD-GMTs AND LGF-PPs (CONT'D)

PARAMETER	LGF-TP	LD-GMT
USE IN LAMINATES	USUALLY NOT	YES ('c)
EXAMPLE APPLICATION	MECHANICAL (d), SEMI-STRUCTURAL (e)	WHEEL ARCH LINER HEADLINER (f) UNDERBODY SHIELDS
LOAD BEARING CAPACITY	HIGHER	

NOTES:

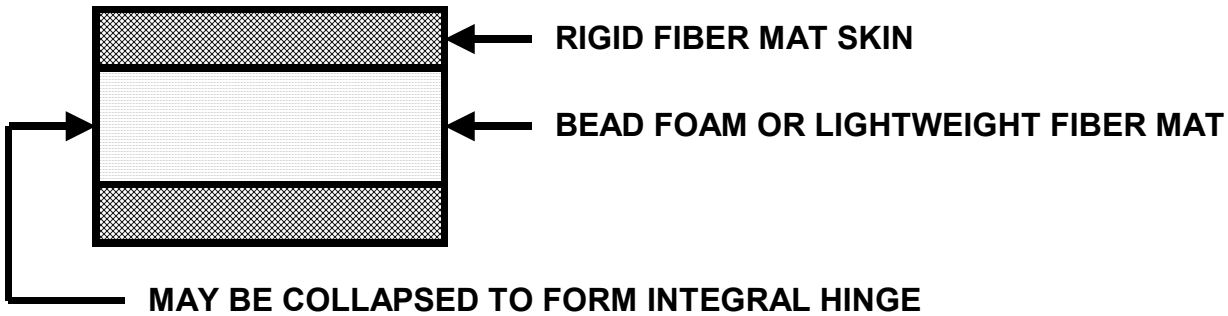
(a) LD-GMTs CAN BE LOFTED TO REDUCE DENSITY
(b) ALUMINUM OR EPOXY TOOLS CAN BE USED
(c) FOR EXAMPLE IN FLOOR MODULES
(d) E.G. DIE CAST METAL REPLACEMENT
(e) E.G RUNNING BOARDS (NANO-COMPOSITES COMPETE IN THIS APPLICATION)
(f) ALSO OTHER INTERIOR SEMI-STRUCTURAL APPLICATIONS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

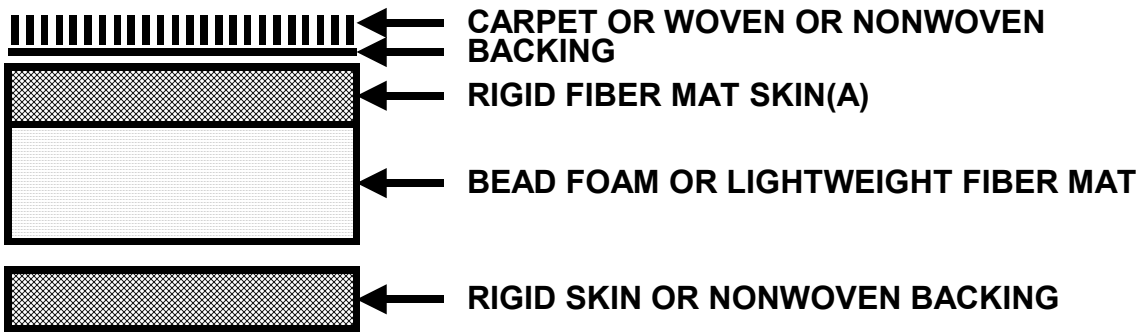
HEADLINER CORE

- **FOAM VS. COMPOSITE BATTLEGROUND**
- **LD-GMTs HAVE PENETRATED**
- **ENERGY ABSORPTION REQ'D (FMVSS 201)**
- **ACOUSTIC PERFORMANCE REQUIRED**
- **ON BOARD EA, ACOUSTICS STARTING**
- **TEXTILE INTEGRATION START?**
- **NEW SUPPLY CHAIN PARTICIPANTS ENTER**
- **SPACE CONSERVATION VALUED**
- **A VALUE ADDED TARGET**

RIGID SEMI-STRUCTURAL FOAM SANDWICH FLOOR STRUCTURE



CARPET/NONWOVEN/WOVEN TEXTILE LAMINATE:



NOTE:
(A) MAY ALSO BE EXTRUDED FOAM SHEET (E.G., FAGERDALA XPP)

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2005

b/mydox/nwmc/nw04-rss foam sand flr 04.vsd
lg/myfiles/visio/nw04-rss foam sand flr 04.vsd

LONG GLASS FIBER THERMOPLASTICS

- **FEMs (VS. HYBRIDS AND HD GMT)**
- **RUNNING BOARDS (VS. NANO COMPOSITES)**
- **DOOR MODULE (VS. SGF-PP, ETP, NFCs)**
- **LOAD FLOORS (VS. LD GMTs, FOAM SANDWICHES)**
- **IP SUBSTRATES**
- **DIRECT COMPOUNDING STARTING**

NANOCOMPOSITES TARGETS

TARGET	KEY PROPERTIES	STATUS	NOTE
EXTERIOR:			
BODY PANEL	STIFFNESS PAINTABILITY, THIN WALL	SEVERAL AT GM	HIGH GROWTH POT'L
GLAZING	LIGHT TRANSMISSION SCRATCH RESISTANCE WEATHERABILITY	EXTENSIVE PRIOR DEVELOPMENT	TARGET FOR GE/EXATEC
BUMPER REINFORCEMENT BEAM	STIFFNESS, IMPACT	CONCEPT	
STEP/RUNNING BOARDS	STIFFNESS	STARTED ON GM VANS IN 2002	GROWTH APPLICATION FOR LG-PP
MIRROR HOUSING	WEATHERABILITY, PAINTABILITY, IMPACT	ABANDONED	TOO EXPENSIVE VS. INCUMBENT

NANOCOMPOSITES TARGETS (CONT'D)

TARGET	KEY PROPERTIES	STATUS	NOTE
INTERIOR:			
FIBERS	**LOW DENIER**	**TORAY INTRODUCTION**	**NANO-CARBON**
STRUCTURAL SEAT BACK	**IMPACT**	**STARTED AT HONDA**	**EUROPEAN "BEER CRATE" LEGISLATION WILL DRIVE**
SIDE IMPACT BEAM	**IMPACT, STIFFNESS**	**CONCEPT**	
TRIM		**CONTRACT IN PLACE**	**EUROPE**

NANOCOMPOSITES TARGETS (CONT'D)

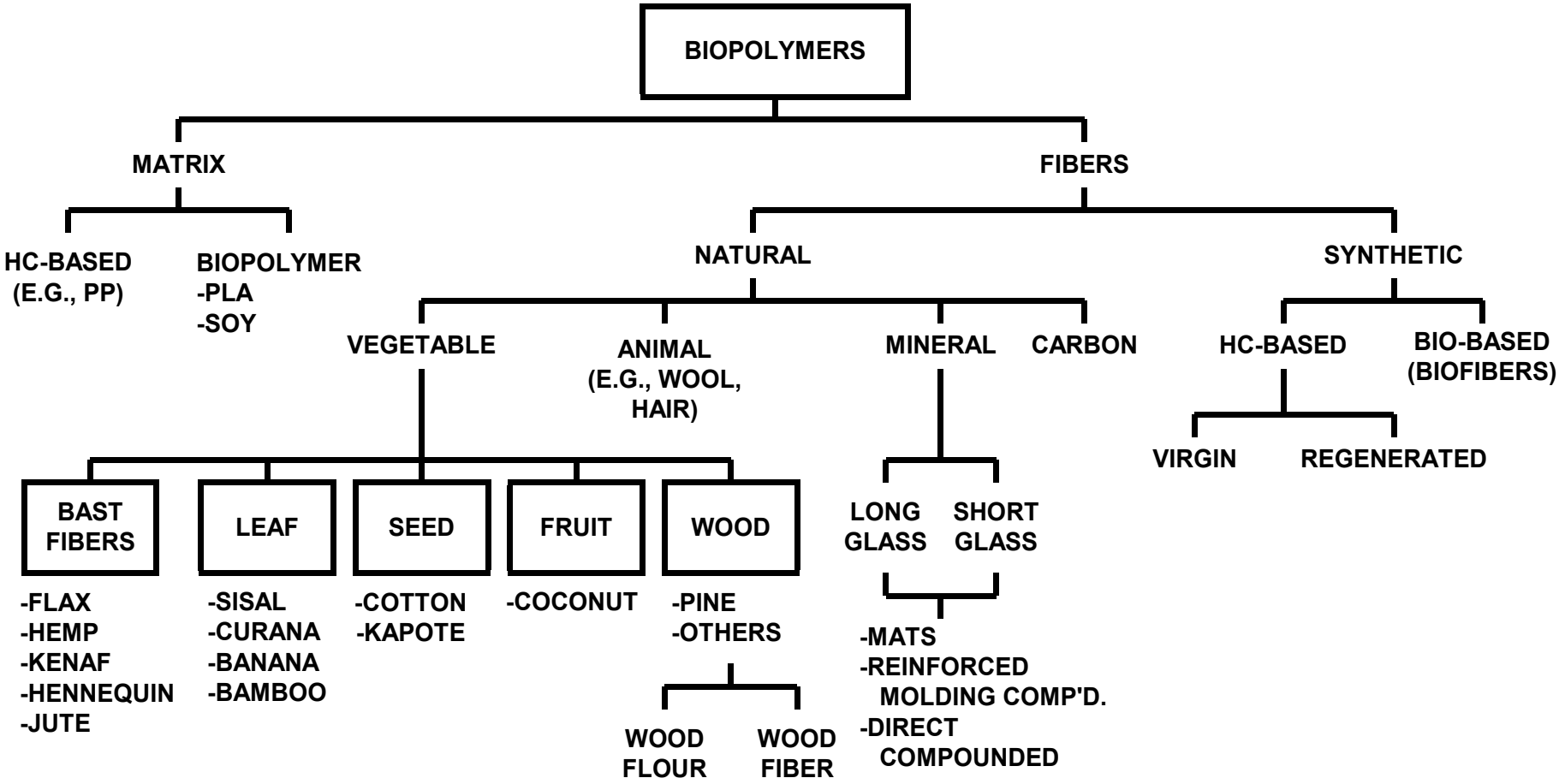
TARGET	KEY PROPERTIES	STATUS	NOTE
UNDERHOOD/FUEL			
FUEL TANK	BARRIER	GROWTH WITH THERMOFORMING	REPLACE EVOH?
FUEL LINE	BARRIER	COMMERCIAL IN JAPAN	EARLY APP IN NYLON NANO-ACETAL (JAPAN)
ENGINE COVER		MITSUBISHI ON GDI MODELS	POOR IMPACT RESULTS AT BASF
TIMING BELT COVER	HEAT RESISTANCE	ABANDONED	

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

NATURAL FIBER COMPOSITES (NFCs)

- **WOOD FIBERS WIDELY USED**
- **BOTH HYDROCARBON AND BIOPOLYMER MATRICES**
- **SYNTHESIZED BIOPOLYMERS STARTING**
- **BROAD FIBER RANGE POSSIBLE**
- **BOTH MAT AND MOLDED PARTS**
- **COMPETE WITH NANO AND GLASS FIBERS?**

BIOPOLYMER CANDIDATES FOR AUTOMOTIVE APPLICATIONS

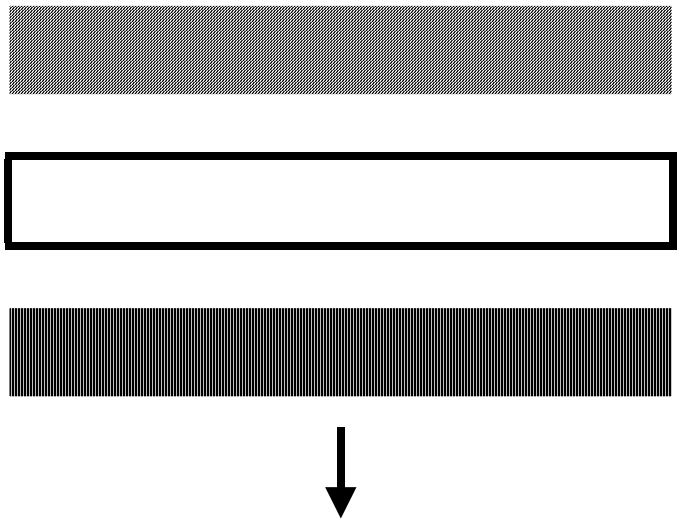


SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

re/mydox/Nissan/Nissan-auto biopolymer 04.vsd
lg/myfiles/visio/Nissan-auto biopolymer 04.vsd

NATURAL FIBER COMPONENTS IN MERCEDES C-CLASS

CONSTRUCTION OF NONWOVEN WHEEL ARCH LINER



NEEDLEPUNCHED NONWOVEN (ZANEVIL(a)); ANTIVIBRATION AND SOUNDPROOFING

EXTRUDED MID-LAYER (PP, EPDM?) (AFONTEX(a))

NEEDLEPUNCHED NONWOVEN(b)

FACING TIRE

NOTES:

(a) PROPRIETARY BRAND FROM SAN VALERIANO

(b) FIBERS ARE VERTICALLY ALIGNED

SOURCE: SAN VALERIANO

b/mydox/nwmc/nw04-wheel arch liner 04.vsd
lg/myfiles/visio/nw04-wheel arch liner 04.vsd

MERCURY MARINER

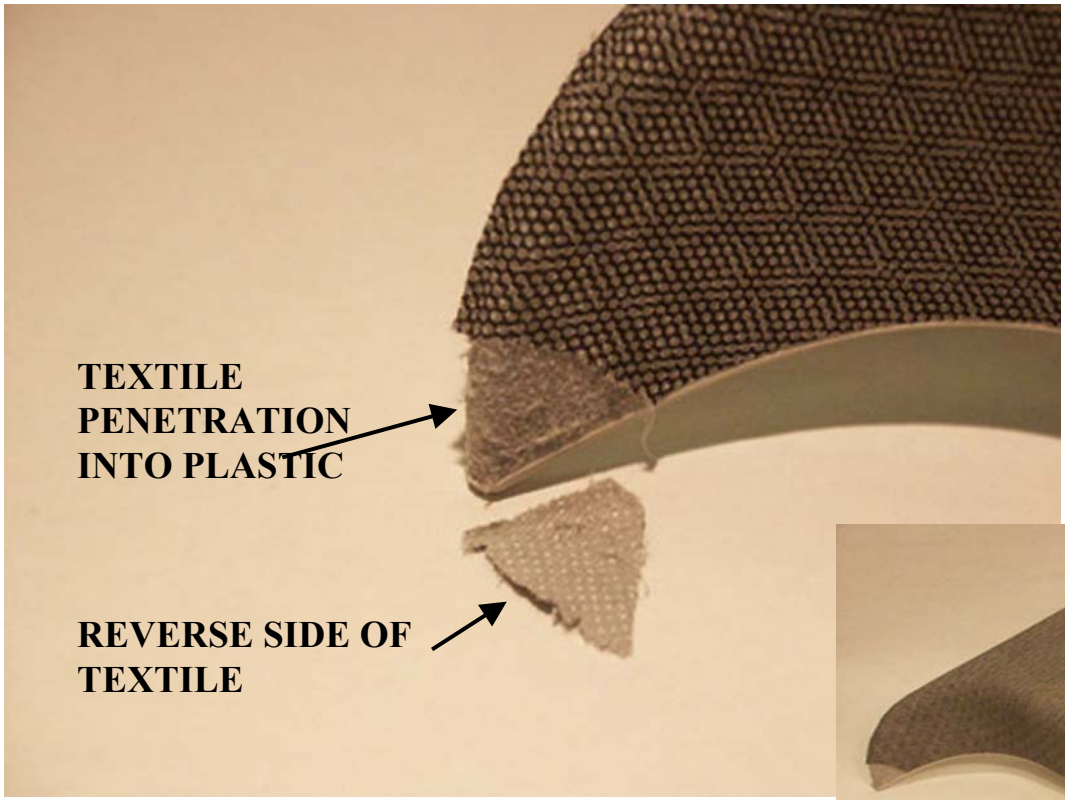
MERCURY MARINER --

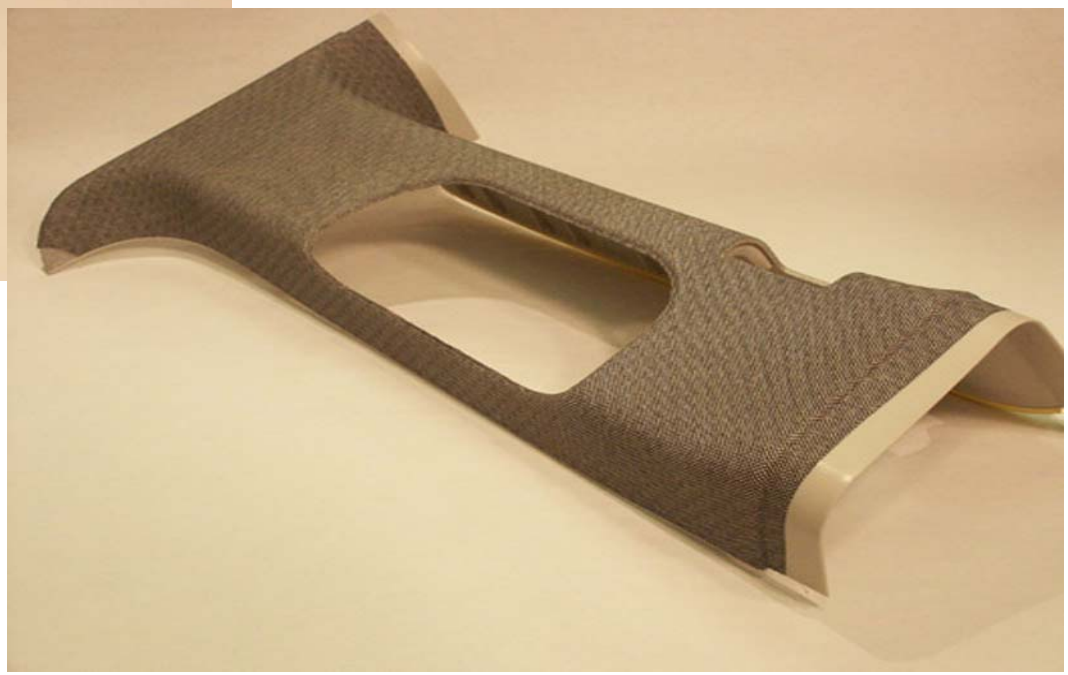
- HARD ABC PILLAR
- VISIBLE PASSENGER AIRBAG DOOR
- KNITTED HEADLINER
- HARD DOOR TRIM PANEL (CLOTH INSERTS)
- HARD INSTRUMENT PANEL
- METAL TRIM ON CONSOLE

MERCURY MARINER

- SHODDY ACOUSTIC BATTING
- HARDBOARD/EPP FOAM STC

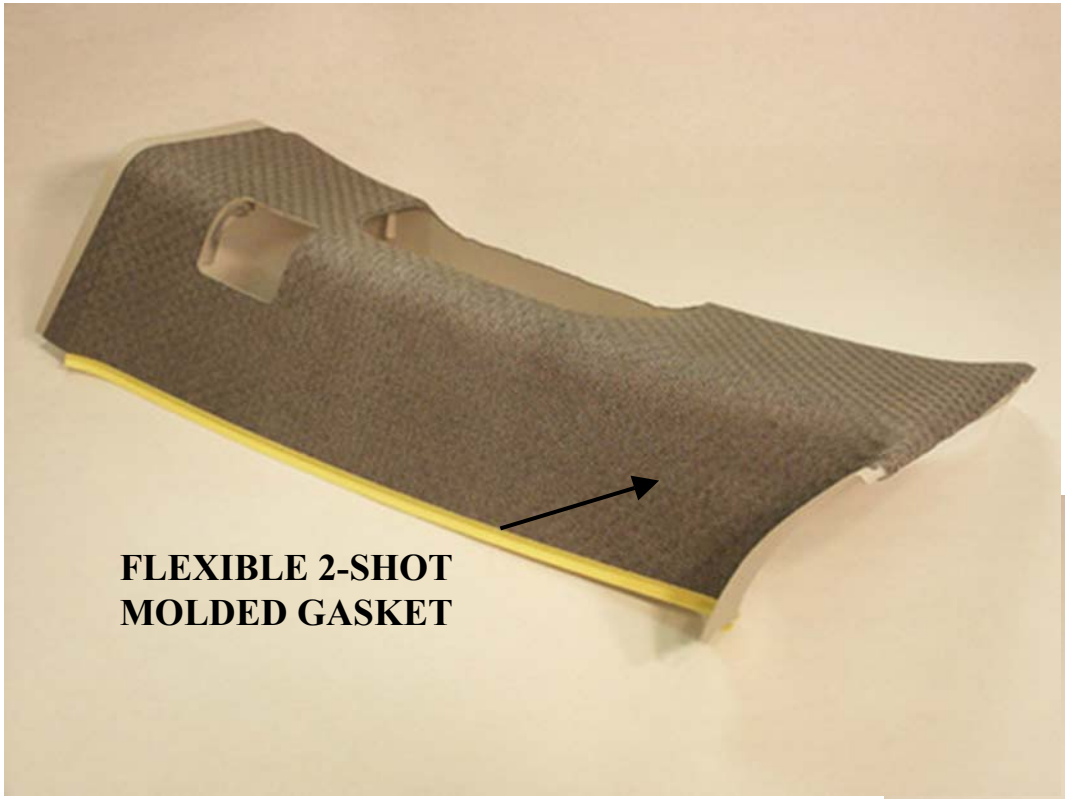
EXAMPLE OF BACK MOLDED PILLAR TRIM

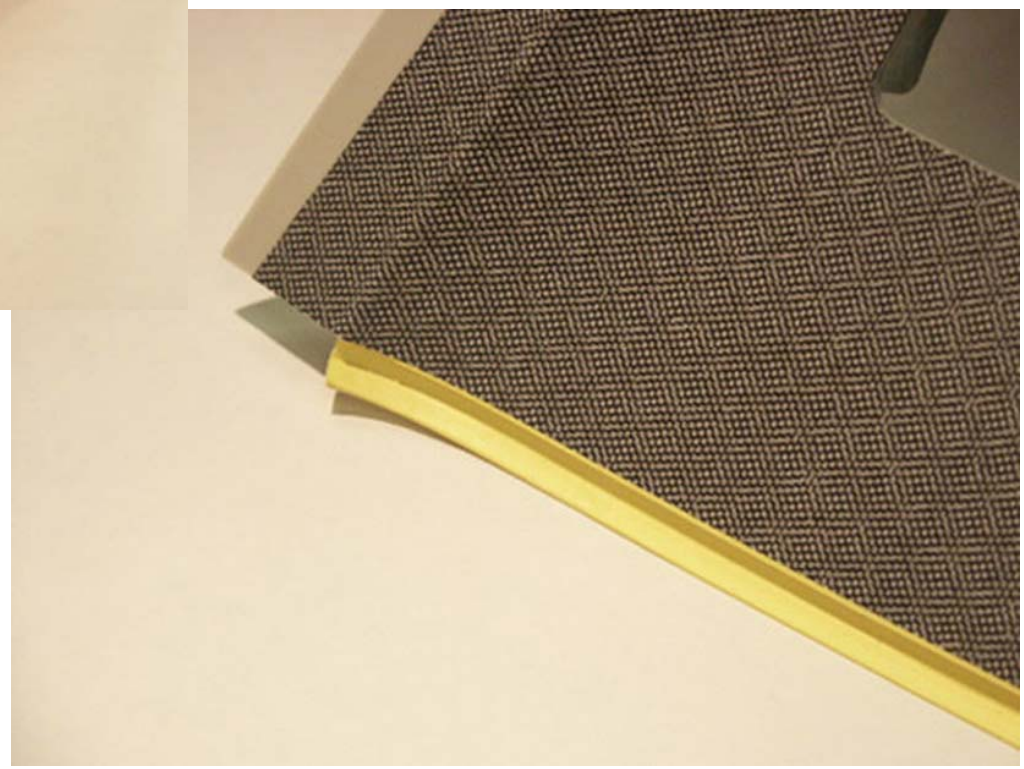




SOURCE: FREUDENBERG, REA PHOTOS

EXAMPLE OF BACK MOLDED PILLAR TRIM WITH NONWOVEN TEXTILES





SOURCE: FREUDENBERG, REA PHOTOS

EXAMPLE OF NONWOVEN TEXTILE (MICROFIBER SUEDE) IN LUXURY TEXTILE APPLICATION

SOURCE: ALCANTARA 2004

SUMMARY

- **AUTO PRICE PRESSURES:**
  - **COMPOSITES INTO LARGER MODULES**
  - **VALUE ADDED OPPORTUNITIES**
  - **COMPOSITE SUPPLY CHAIN SHIFT**
- **COMPOSITE OFFERINGS BROADENING**
- **RANGE OF PERFORMANCE LEVELS**
- **INTRA-COMPOSITE COMPETITION**
- **EXPANDED PROPERTY ENVELOPE**