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DRIVING FORCES FOR FOAM SUBSTITUTION IN AUTOMOTIVE INTERIOR SOFT TRIM

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Presented by: Robert Eller

OVERVIEW

Polyurethanes dominate current automotive foam usage due to their position in seating, textile laminations, and acoustic barriers. Polyurethanes are facing an initial challenge in seating foam, but a major shift toward alternative foams appears to be unlikely. Polyolefin foams, on the other hand, will experience substantial growth and inter-foam competition in automotive applications such as:

- Energy absorption
- Some acoustic applications
- Semi-structural applications
- Body and glazing seals
- Textile laminates
- Seating

In a companion paper presented at this Conference (Reference 6), we have analyzed the driving forces for material substitution in interior soft trim modules and identified strategies for creating value.

Foams play a key role in the interior soft trim value chain. In this paper, we will review:

- The functions of automotive foams in interior soft trim
- Driving forces for foam substitution and differences between Europe and N. America
- Enabling technologies that will influence the position of polyolefin foams
- Intermaterials competition between foam challengers and non-foam incumbents
- Implications of soft trim materials and process technology shifts on foam usage
- Unrealized, value-added opportunities for foams.

The observations and conclusions described in this paper are partly based on recent research and REA's multiclient analyses of auto interiors in Europe and N. America (see Appendix 1 and References 1-4).

References and a list of abbreviations are included in the Appendix to this paper.

AUTOMOTIVE FOAM APPLICATIONS

The applications in which there is inter-foam competition and growth opportunities are illustrated in Exhibit 1.

AUTOMOTIVE FOAM TYPES

Automotive foams can be characterized by shape, resin type, crosslinking method, foaming method, cell structure, and density. The foam families competing in the auto interior soft trim market are listed below and summarized in Exhibit 2.

AUTOMOTIVE FOAM SHAPES AND APPLICATIONS

FOAM SHAPE	FOAM CANDIDATES	EXAMPLE APPLICATIONS
MOLDED	-STEAM CHEST MOLDED BEAD FOAMS (PRIMARILY EPP) -PU FOAMS	-SUN VISORS -ENERGY ABSORBERS -SEMI STRUCTURAL APPLICATIONS -FLOOR ACOUSTIC BARRIERS -SEATING
SHEET	-SKIVED PU (INCUMBENT) -INTEGRAL SKIN/FOAM PVC -EXTRUDED PO (XLINK, NON-XLINK)	-INSTRUMENT PANEL SKINS -DOOR TRIM PANEL SKINS -TEXTILE & SKIN/FOAM LAMINATES -GASKETING
THICK SHEET	-DOW's STRANDFOAM®	-ENERGY ABSORBERS (DOOR TRIM, HEADLINER)
PROFILES	-TPV, SEBS?	-BODY/GLAZING SEALS

Note: Only some steam chest molded foams have acoustic properties.

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

Steam Chest Molded Bead Foams -- Steam chest molded bead foams (typically EPP), have an established position in automotive dunnage and bumper energy absorbers in North America. (European bumper energy absorber penetration is considerably lower, but fast growing to meet new European pedestrian standards.) EPPs must compete for non-bumper automotive applications with:

- PPO-based bead foams
- Polyolefin-based blends
- Polyurethane foams
- Several types of honeycomb
- Extruded thick sheet foams (e.g. Dow's Strandfoam®)
- Lightweight fiber (PET, PP) -based composites

Bead foams offer a number of advantages including:

- Energy absorption during multiple impact
- The ability to vary density both in the xy plane and along the z-axis
- Acoustic absorption properties (when open-celled)
- Semi-structural properties (when incorporated into a rigid skin/foam laminate such as shown in Exhibit 3)
- The ability to be formed into living hinges (EPP only)

The potential applications for EPP bead foams are listed in Exhibit 4. Only a small portion of the potential for bead foams in automotive interior applications has been realized to date. We estimate that potential demand for EPP bead foams in North American and European auto interiors at full substitution (headliners, knee bolsters, load floor systems, door trim panels, sun visors, etc.) is 60 kT (125MM lbs.)

Thin Sheet Foams -- Radiation crosslinked polyolefin (XLPO) sheet foams currently supplied by Sekisui and Toray dominate this sector. They are valued for their soft touch and thermoformability when used in combination with TPO (or PVC) skin/foam laminates for applications such as instrument panels (IP) and door trim (DT).

Lamination of XLPO foams with textiles to compete with textile/skived PU constructions is in the early development stages. Typical foam thicknesses are 2.5 mm with densities in the 2.5-4.0 lb./ft.^{3} range (40-64 kg/m^3). Non-radiation crosslinked polyolefin sheet foams are entering this sector based on HMS PP resin and alternative crosslinking (e.g., chemical) technologies.

Thin sheet foams will grow with the increased use of skin/foam and textile/foam laminates in auto interiors. The skin and textile/foam laminates must compete with:

- Non-laminated TPO compact skins
- Thermoformed PVC skins
- Sprayed PU skins (Recticel process)
- Slush molded PVC and TPU skins
- Textile/PU foam laminates.

Skin and Textile/Foam Laminates -- Textiles are generally used in interior applications such as laminates with PU sheet (skived) foams in order to achieve a soft contour and soft touch, padded effect. The typical construction is a polyester or knitted jersey textile, flame laminated to the PU foam sheet. These laminates are used in typical interior body cloth applications (headliner, sun visor, seating, door medallions). Recently, textile/polyolefin foam laminates have been introduced in French vehicles and are likely to appear in German models in the near future. Initial penetration has been in small applications such as the door medallion. In addition to avoiding the necessity of flame lamination, the introduction of polyolefin foams into the laminate offers the prospect for an all-polyolefin construction if polypropylene (PP) textiles are used in applications such as door trim panels. The use of PP textiles in auto interiors has previously been restricted by UV resistance and limited color range. These limitations appear to be in the process of being overcome. As described in our companion paper (Reference10), polyolefin foam lamination is slower than PU foam lamination.

PROFILE FOAMS

Profile Foams -- Body and glazing seals are the major automotive applications for foamed profiles. Typical applications include hood, rear deck, door, and some window seals. The total market potential at full substitution for the incumbent EPDM foams in these applications is 280 kT in the N. American and European fleets (Reference 5).

The dominant automotive incumbents are foam (sponge) and solid (dense) EPDM, usually used in the same profile. TPEs (primarily TPVs, thermoplastic vulcanizates) are penetrating the body seal sector primarily based on:

- Colorability (e.g., to match or complement body panel colors)
- Improved long term weather resistance
- Systems cost savings when combined with thermoplastic fasteners and profiles.

Foam quality (cell size, skins quality, cell size distribution) is still inferior to that of EPDM-based foams and is a limitation to further development. Current efforts are being directed toward improvement of TPE foam characteristics. The development sequence of foaming technology in this sector has been:

- Water-blown foam profiles
- Combinations of water and chemically blown foams
- Microcellular blown foams based on critical fluid blowing agent technology (e.g., MuCell).

DRIVING FORCES FOR AUTOMOTIVE FOAM SUBSTITUTION

The drivers for foam substitution are listed in Exhibit 5.

Some of the driving forces (e.g., energy management) are a *direct* stimulus to increased polyolefin foam substitution. In other cases, polyolefin foam penetration will increase because of *indirect* driving forces such as:

- The desire for colored body seals (extruded TPE foams)
- The cost savings associated with parts consolidation
- Substitution for PVC skins (thin sheet foams)
- Elimination of flame lamination
- Lower cost constructions
- Enhanced recyclability.

Driving Factors for Polyolefin Foam Substitution -- Some of the factors that will accelerate the growth of polyolefin foams in automotive interior soft trim are:

- Replacement of water blown foams in TPE body seals
- The growth of polyolefin microcellular technology in body seals and sheet foams
- The proliferation of radiation crosslinking polyolefin foam technology
- The entry of low cost, non-crosslinked polyolefin sheet foams
- The development of polyolefin foam/textile laminates (e.g., for door trim medallions)
- The market penetration of extruded thick sheet foams (e.g., such as Dow's Strandfoam®)
- The development of in-mold skin (or textile)/EPP foam lamination processes
- The further development of multi-density EPP bead foams
- The development and proliferation of injection molded and extruded rigid sheet foams

Foams in Body Seals -- Current trends are pointing to at least a partial substitution of thermoplastic elastomers (TPEs) for the thermoset rubbers that are used in body and glazing seals. In order to advance this substitution, improved foaming techniques must be developed for the TPEs.

Weight Saving -- has been a constant feature of the automotive competitive arena. It has grown in importance with the re-emphasis on corporate average fuel economy (CAFE) requirements and the desire by auto OEMs in N. America to retain the highly profitable SUV market via reduced fuel consumption. It is of particular importance in the foam sector due to the ability to form high stiffness/light weight rigid skin/foam laminates for growth applications such as load floors as illustrated in Exhibit 3. Weight saving is also a major driver in the use of lightweight fiber constructions in the floor/acoustic module.

Energy Management -- As with the earlier penetration into bumper systems in N. America and more recently in Europe, energy management has become a key driving force for polyolefin foams in interiors. Bead foams, in particular, will benefit from this trend as illustrated by the applications shown in Exhibits 11 and 12.

Acoustic Properties -- Improved acoustic performance is a major driving force in automotive interiors. This applies to both exterior noise (primarily tire noise) and interior airborne noise (to accommodate increased use of telematics). The competitive environment in which polyolefin foams must compete for a position in acoustic systems is illustrated in Exhibit 6.

If the acoustic improvement can be incorporated onto the substrate panel (on-board acoustics), value is enhanced. Floor and overhead systems are prime targets for this high value property combination. Polyurethane foam systems are the key incumbent. Recently, Huntsman has developed the capability to produce acoustically tailored polyurethane foams for both of these large-area interior modules.

Due to their closed-cell structure, bead foams have poor acoustic absorption properties. The creation of interstices within the bead foam structure provides multi-fold improvement in acoustic absorption. JSPI has developed this approach to acoustic performance in bead foams.

Competition with Regenerated Felt Constructions -- Regenerated cellulosic fibers are widely used as an acoustic barrier in floor, seat backs, package trays, and trunk floors (see Exhibit 1). Although inexpensive, this material has a number of disadvantages (most notably water pickup and loss of compression resistance properties with time).

Floor systems are a major use of regenerated fiber constructions. The usage of foams and fibers for acoustic constructions differs between N. America and Europe as illustrated in the table below:

USE OF ACOUSTIC BARRIER MATERIALS IN AUTOMOTIVE FLOORING

MATERIAL	CURRENT SHARE, %		NOTE
	EUR.	N.A.	
REGEN. CELLULOSE FIBERS (SHODDY)	20	50	USE WILL DECLINE IN BOTH REGIONS
PU FOAM	75	45	TUNED ACOUSTICS ACCELERATE PENETRATION
OTHER CHALLENGERS:	5	5	
POLYOLEFIN FOAMS			ACOUSTIC PROPERTIES MUST BE IMPROVED
PET/PP FIBERS			NEW LIGHTWEIGHT FIBER CONSTRUCTIONS(A)
MICRO-DENIER NONWOVENS			AS ACOUSTIC MODULATOR

Note: (A) Lightweight fiber construction usage will increase.
SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

Low V.O.C. Interior -- Reduction of V.O.C.s is emerging as a key driving force for the selection of interior materials. Early pressure has come from European OEMs and is likely to spread to N. America.

KEY FUNCTIONS OF AUTOMOTIVE FOAMS

The key functions of automotive foams by module type are listed in Exhibit 7 and by foam type in Exhibit 8.

NEW FOAM TECHNOLOGIES

Both resin developments and foam process technology are accelerating polyolefin foams' penetration into automotive applications as summarized in Exhibit 9.

Microcellular Technologies -- The use of critical fluids as blowing agents produces extremely fine cell size and uniform cell size distribution. When cell size approaches the micron range, the normal property/density relationships are significantly improved. This technology is likely to open a new range of polyolefin foam automotive applications in body seals, sheet foams, and energy absorbing foams.

HMS Resins -- The use of high melt strength (HMS) PP resins improves both:

- Rheology during the cell formation stage
- Thermoforming characteristics (critical for sheet foams).

HMS resins are being offered by Borealis, Basell, and Chisso as raw materials for both sheet and bead foams.

TPEs -- Thermoplastic vulcanizates (TPVs) compete with foamed EPDM in profile extrusions such as automotive body seals (see Reference 3). Initial penetrations were based on water-blown foaming technologies, which provided adequate cell size control and surface quality for body seals. Recent improvements (probably involving chemical blowing agents, alone or in combination with water) have produced more competitive cell size and distribution, better gas retention, and surface qualities for competition in this key target sector vs. sponge EPDM.

Functional Profiles -- Extruded functional profiles (such as tubing) from polyolefin foams provide a light weight solution for the passage of air in HVAC applications.

European/N. American Differences -- As shown in Exhibit 10, there are significant differences between the European and N. American automotive sectors with respect to current use and conditions for future use of polyolefin foams in interior and exterior applications.

SUMMARY

Polyolefin sheet, bead, and profile foams will grow in automotive applications driven by energy absorption, semi-structural, and esthetic functions. Bead foams, in particular, are currently under-utilized with respect to their potential. Acoustic performance is a key foam driving force, which will not benefit polyolefin foams unless open-celled structures are developed.

European and North American automotive foam usage patterns are different and are converging.

New resin and foam process technology (metallocenes, HMS resins, microcellular foams, combinations) are broadening the price/performance envelope for both sheet and bead foams.

Body seals are emerging as a major growth application for olefinic TPE foams. The ability to provide foam profiles with predictable, improved properties is an example of the use of foams enabling the growth of a new application.

Foams have the potential for adding value both to the foam itself and to the module into which the foam is incorporated via integration into semi-structural composites, reducing processing steps to produce interior components, improving on-board acoustic performance and functional profiles such as ducting.

ABBREVIATIONS USED IN THIS PAPER

CAFE	- Corporate average fuel economy
EA	- Energy absorber
BF	- Bead foam
EPP	- Expanded PP (or PP copolymer) bead foam
ESI	- Ethylene styrene interpolymer
E-PPO	- Expanded Noryl/PS bead foam
GF	- Glass fiber
HMS	- High melt strength PP
HVAC	- Heating, ventilation, and air conditioning
NVH	- Noise, vibration, harshness
TPE	- Thermoplastic elastomer
TPV	- Thermoplastic vulcanizate
UEV	- Unsupported expanded vinyl (e.g., PVC foam)
V.O.C.	- Volatile organic compounds
XLPO	- Crosslinked polyolefin (usually sheet foam)

AUTHOR'S BIO

Robert Eller is President of Robert Eller Associates, Inc. (REA), a consulting company providing analysis and support of management decision-making in the automotive plastics and rubber industries. REA has offices in North America (Akron, Ohio), France, Switzerland, and Spain. His coordinates are: 4000 Embassy Parkway, Suite 230, Akron, Ohio 44333, USA; Phone: 330-670-9566; E-mail: bobeller@prodigy.net; Home Page: http://www.robertellerassoc.com.

His firm has completed numerous single-client studies in automotive plastics and multi-client studies (see References) of:

- Automotive interior soft trim in Europe and N. America
- The role of advanced nonwoven textiles in automotive interiors (study underway)
- Automotive instrument panels (photo/supplier databases for Europe and N. America)

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3. European Automotive Instrument Panels and Supplier/Materials Database CD-ROM, Robert Eller Associates, Inc., 2002 (a searchable photo and supplier database)

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5. Multiclient Study, "SEBS, TPV and TPO-type Thermoplastic Elastomers . . . Markets, Economics, Technology, Intermaterials Competition and the Role of Metallocene Resins," Robert Eller Associates, Inc. (2000)

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10. “Developing Low Pressure Injection Molding for Door Panels,” Plastics in Automotive Interiors (Frankfurt, Germany), October 2003; J. M. del Brio

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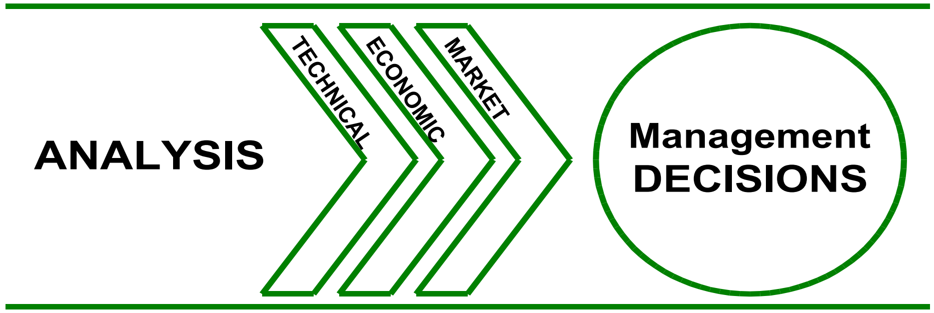
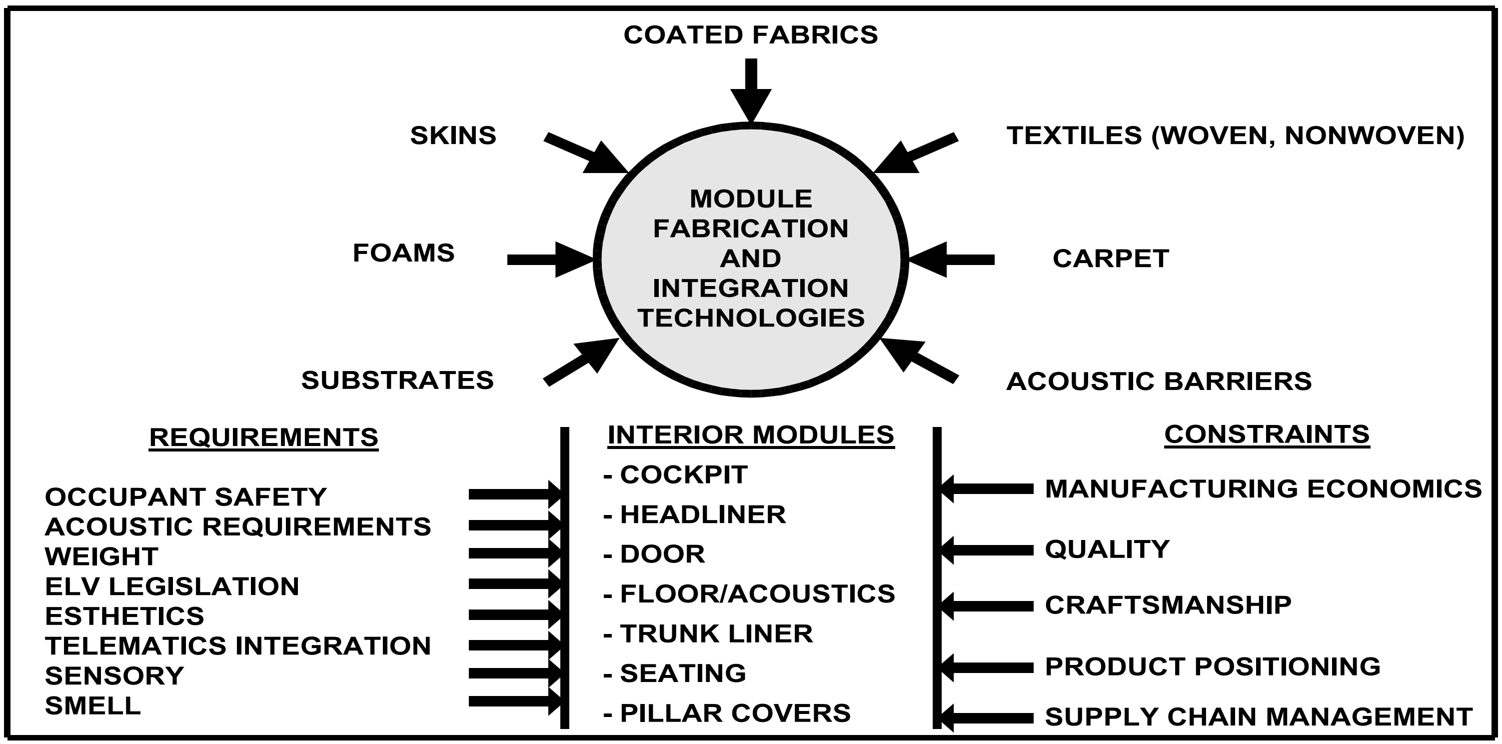


Automotive Interior Soft Trim:

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



Prospectus for a Global Multiclient Industry Analysis

Robert Eller Associates, Inc.

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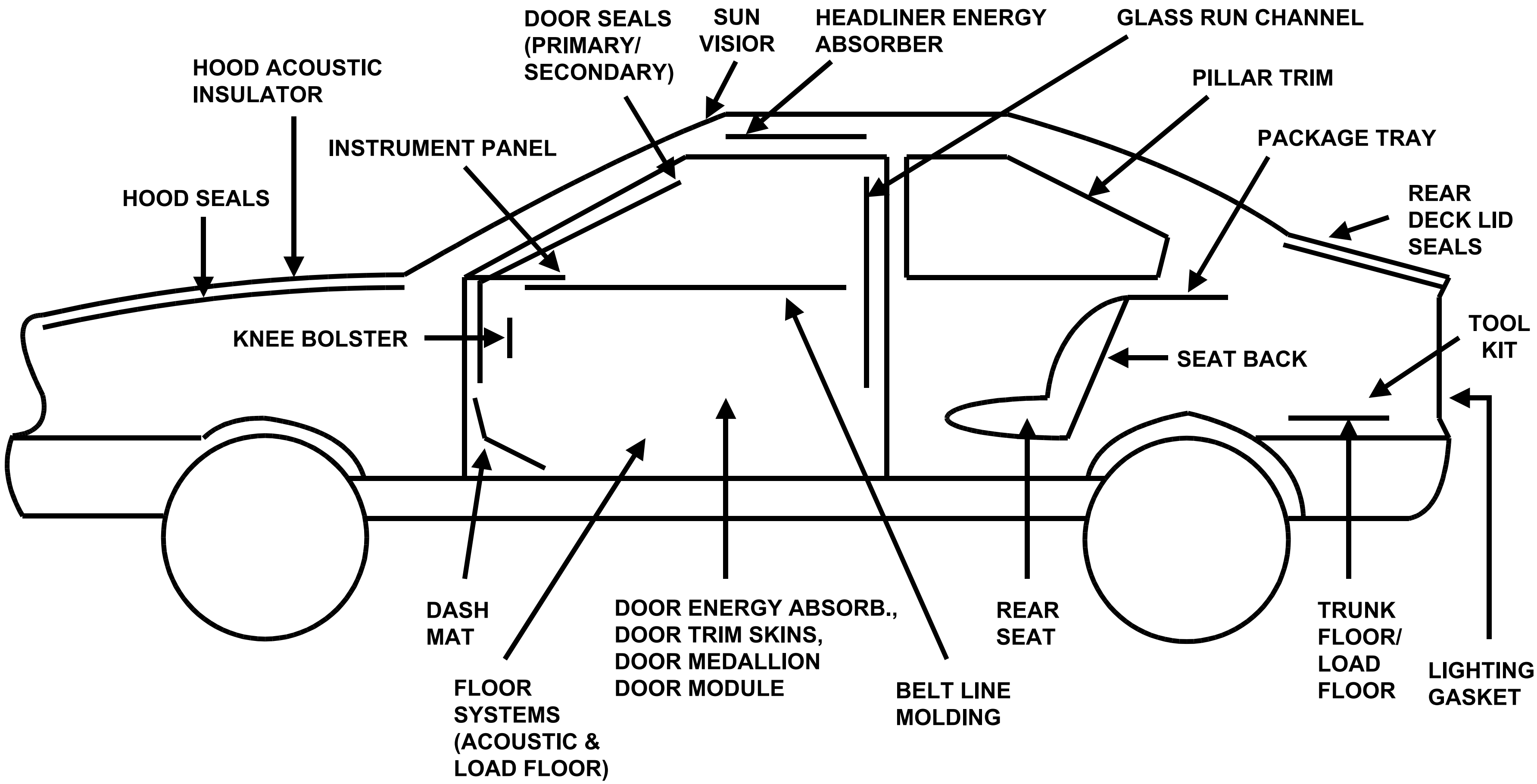
EXHIBIT 1

AUTOMOTIVE INTERIOR APPLICATIONS



SOURCE: ROBERT ELLER ASSOCIATES, INC. SOFT TRIM MULTICLIENT STUDY, 2003

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EXHIBIT 2

AUTOMOTIVE FOAM FAMILIES AND EXAMPLE APPLICATIONS

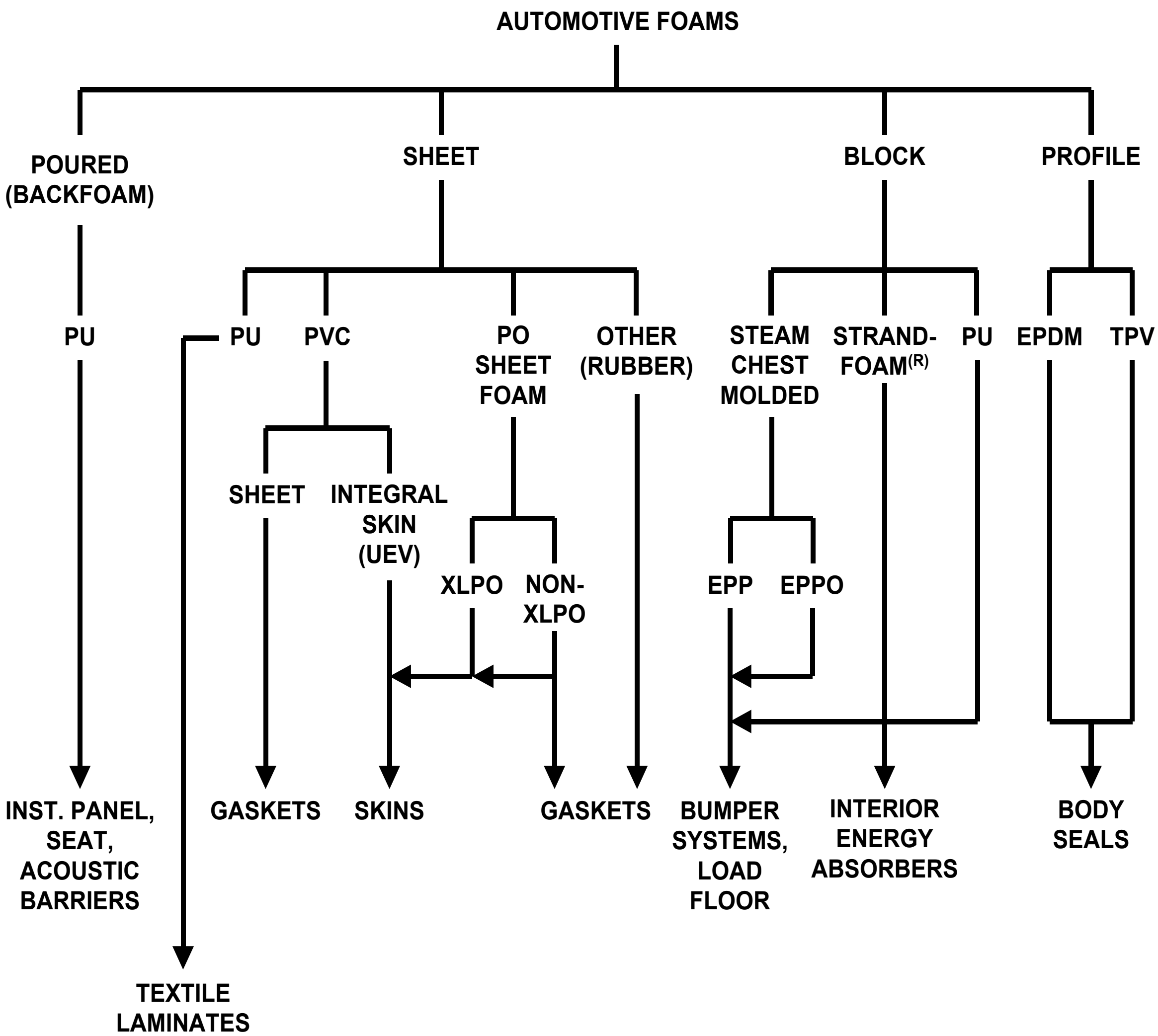

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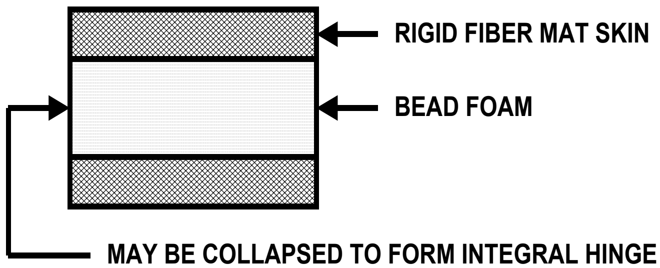
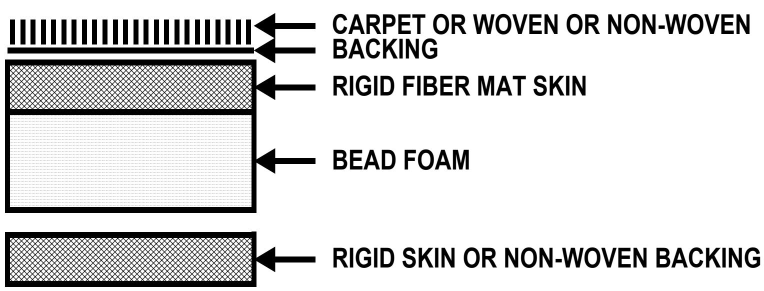
EXHIBIT 3

RIGID SEMI-STRUCTURAL FOAM SANDWICH STRUCTURE

BARE:



CARPET/NON-WOVEN/WOVEN TEXTILE LAMINATE:



SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

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EXHIBIT 4

POLYOLEFIN BEAD FOAM COMPETITORS AND APPLICATIONS

PART	COMPETITIVE PROCESSES	BEAD GROWTH POTENTIAL	NOTE
SUN VISOR	-CARDBOARD -SKIVED PU* -INJ . MOLDED*	EPP GROWTH	-EPP ESTABLISHED IN EUROPE AND JAPAN -STARTING IN N. AMERICA
TOOL BOX		EPP GROWTH	GROWING FLEET PENETRATION
HEADLINER	-FIBER BASED* -EXTRUDED FOAMS -PU FOAMS*	LOW?	GROWTH AS RIGID SKIN/FOAM LAMINATE
HEADLINER ENERGY ABSORBERS	-PU FOAMS -STRANDFOAM®	EPP GROWTH	-FOR ENERGY ABSORBER LATERALS -INTEGRATED INTO HEADLINER
DOOR TRIM PANELS	-LOW PRESS MOLD* -CELLULOSICS* -S-RIM	-EPP GROWTH -EA DRIVER	-INTENSE INTERMATERIALS COMPETITION -NOTE S-RIM ON GMT 800 -NATURAL FIBER COMPOSITES?
HEADREST	-BLOW MOLD -PU FOAM*	EPP/EPPO GROWTH	
KNEE BOLSTER	-STRUCTURAL IM -BLOW MOLD -GMT	HIGH	-INTEGRATION WITH INSTRUMENT PANEL
CARPET UNDERLAY	-PO FOAMS -PU FOAMS* -PLASTIC FIBERS -SHODDY*	-? -START IN EUROPE	-DIFFICULT INTERMATERIALS COMPETITION
ABC PILLAR	-INJ. MOLD* -EA FOAMS	LIMITED	-INJECTION MOLDING IS CHEAPER
INSTRUMENT PANEL	-INJ. MOLD* -BLOW MOLD	STARTING	-INTEGRATION WITH STRUCTURAL IP?
CONSOLE	-INJ. MOLD*	LIMITED	-NO SUCCESS YET/DESPITE EFFORT
PKG. TRAY	-CELLULOSICS* -LOW PRESSURE*	LIMITED	-NO SUCCESS YET/DESPITE EFFORT

NOTE: * = DOMINANT INCUMBENT

**SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003**

EXHIBIT 5

DRIVING FORCES FOR AUTOMOTIVE FOAM GROWTH AND MATERIALS SUBSTITUTION

DRIVING FORCE	ACTUAL OR POTENTIAL CHANGE	MATERIALS/PROCESS IMPLICATIONS AND EXAMPLES
ACOUSTIC PERFORMANCE	-REDUCED DRIVE-BY NOISE -REDUCED INTERIOR AIRBORNE NOISE	-'TUNED' ACOUSTICS/FLOOR MODULE -LIGHTER WEIGHT ACOUSTICS SYSTEMS
INTERIOR EMISSIONS	-NO-SMELL INTERIOR -REDUCED V.O.C. EMISSIONS -LOW FOGGING LEVELS	-LOW V.O.C. PU FOAMS, SKINS -NON OIL-MODIFIED TPEs -ELIM. HOT POUR PU FOAM SEATING -ENHANCED POSITION FOR PO FOAMS?
OCCUPANT SAFETY	HEAD AND SIDE IMPACT REGULATIONS(A)	-INCREASED USE OF ENERGY ABSORBING FOAMS(B)
UTILITY FUNCTION/LOOK	-NON-CARPET FLOORING -INSTRUMENT PANEL SKINS -INVISIBLE AIRBAG DOORS	-TPO (TPU?) SHEET FLOOR/ACOUSTICS MODULE -ALL-POLYOLEFIN FLOOR MODULE? -TECHNICAL GRAIN IP SKINS
END OF LIFE RECYCLING	-ELV LEGISLATION	-MONOMATERIAL SANDWICHES -RECYCLATE CONTENT (AT NO COST INCREASE) -TEXTILE/PO FOAM LAMINATES -NATURAL FIBER COMPOSITES
COLOR MATCH	-COLOR MATCHED BODY/GLAZING SEALS	-TPE GROWTH IN BODY/GLAZING SEALS
SKINS GRAIN	-GRAIN RETENTION DURING FORMING	-INCREASED USE OF SLUSH, PU SPRAY -RIM-PU SKIN PROCESSES -NEGATIVE THERMOFORMING OF TPO SKINS
FLOOR SPACE MANAGEMENT	-SEMI-STRUCTURAL SANDWICHES	-AZDEL/EPP FOAM/TEXTILE LAMINATES
LOW TEMP PERFORMANCE	-AIRBAG DEPLOYMENT WITHOUT SHARDS	-NON PVC GROWTH IN IP SKINS
PROCESS COST REDUCTION	-MODULARIZATION -PARTS CONSOLIDATION -SANDWICH CONSOLIDA'TN.	-DIRECT COMP'DG./FABRICATION -ON-BOARD ACOUSTIC BARRIERS -"POPULATED" PANELS -HARDWARE CASSETTES (E.G., DOOR MODULES) -ON-BOARD ENERGY ABSORBING FOAMS
WEIGHT SAVINGS	-FOAMED DUCTING	-REDUCES NVH

NOTES:
(A) IN PLACE IN N. AMERICA; STARTING IN EUROPE
(B) ESPECIALLY IN DOOR TRIM AND HEADLINERS

SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

EXHIBIT 6

INCUMBENTS/CHALLENGERS IN AUTOMOTIVE ACOUSTIC SYSTEMS

INCUMBENT	BARRIER TYPE		CHALLENGER	EXAMPLE LOCATION
	DAMP	INSULATE		
GLASS FIBER		X	-PLASTIC/CELLULOSE FIBERS	HOOD, OH SYSTEM
FILLED POLYMER(A)	X		-METALLOCENE POs -LIGHTWEIGHT FIBER CONSTRUCTIONS	DASH, FIREWALL, FLOOR/ACOUSTICS
MASTIC	X		-IMPROVED MASTIC	FLOOR
PU FOAM (SKIVED)		X	-POLYOLEFIN SHEET FOAMS IN TEXTILE LAMINATES	FLOOR, DASH, OH SYSTEM
PU FOAM (POURED)(D)		X	-EPP BEAD FOAMS(C)	FLOOR PANELS
REGENERATED FIBERS(B)		X	-PLASTIC FIBERS -LIGHTWEIGHT FIBER CONSTRUCTIONS	FLOOR, DOOR, HEADLINER

NOTES:

(A) SEBS (E.G., KRATON) OR EVA

(B) E.G., SHODDY

(C) IN USE AT BMW (3-SERIES)

(D) CAN BE ACOUSTICALLY TUNED (HUNTSMAN TECHNOLOGY)

**SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003**

EXHIBIT 7

KEY FUNCTIONS OF AUTOMOTIVE FOAMS BY MODULE TYPE

MODULE/ COMPONENT	INCUMBENT	KEY FUNCTIONS	FOAM CHALLENGER	NOTE
SEATING	PU	CUSHION	EPP?	MINOR CHALLENGE
HEADLINER DOOR TRIM	SKIVED PU/TEXTILE LAMINATES	ACOUSTIC, CUSHION	XLPO?	MINOR CHALLENGE
BODY SEALS	EPDM	SEAL	TPV	REQUIRE C-SET SURFACE QUALITY
IP/DT SKIN/FOAM	POURED PU INTEGRAL SKIN PVC	SPACE FILL ACOUSTIC SOFT TOUCH	-NEW PROCESSES -ELIM. SKINS -BEAD FOAMS -SHEET FOAMS	TPO SKIN/XLPO GAINING SHARE
ACOUSTIC/ FLOOR	PU SHODDY	ACOUSTIC BARRIER	EPP (OPEN CELL?) PLASTIC, NAT FIBER	EPP NEEDS ACOU PROPERTIES
HOOD LINER	GLASS FIBER	ACOUSTIC BARRIER	EPP (OPEN CELL?) PLASTIC, NAT FIBER	STRONG REPLACE TREND
DOOR TRIM SUBSTRATE	CELL. FIBER INJ. MOLD	SEMI-STRUC	EPP S-RIM	
GASKETS	RUBBER, PVC	SEAL	PLASTIC, NAT FIBER	

**SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003**

EXHIBIT 8

AUTOMOTIVE INTERIORS FOAM COMPETITION BY FOAM TYPE

TYPE	APPLICATIONS	NOTE/COMPETITOR
PU:		
POURED	SEATS	PET FIBERS; MINOR CHALLENGE
CAST	ACOUSTIC FLOORS	PARTIAL REPLACEMENT BY BEAD FOAMS?
CAST/GLASS REINFORCED	HEADLINER	UNDER ATTACK BY PET BEAD FOAMS
SKIVED	TEXTILE LAMINATION HEADLINERS	XLPO SHEET
BACKFOAM	INSTRUMENT PANEL	BEAD FOAM? SHEET FOAM
PRESSED SCRAP	ACOUSTIC FLOOR TRUNK	SHODDY
LD-R-RIM	DT PANELS	NFCs, LD-PP
POLYOLEFINS:		
XLPO SHEET	IP, DOOR TRIM	LAMINATES
POLYOLEFIN BEAD (EPP)	ENERGY ABSORBERS SEMI-STRUCTURAL	BUMPER IS MAJOR APPLICATION; LOW REALIZATION OF POT'L.
ACOUSTIC BEAD	FLOOR	JSPI
EXTRUDED TPV	BODY SEALS vs. EPDM SPONGE	GROWTH APPLICATION
EXTRUDED METALLO-POs	GASKETS	E.G., BY SENTINEL
THICK SHEET	ENERGY ABSORBERS	E.G., BY DOW
OTHER:		
INTEGRAL PVC (UEV)	SKINS	REPLACEMENT TARGET; INTEGRAL SKIN REDUCES COST
BEAD PPO (E-PPO)	ENERGY ABSORBERS	EPPs NEAREST BEAD FOAM COMPETITOR
BEAD SMA	ENERGY ABSORBERS	EARLY USE, HIGH HEAT APPLICATIONS
BEAD PO BLENDS	ENERGY ABSORBERS	E.G., ARCEL

SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

EXHIBIT 9

TECHNOLOGY DRIVERS/ENABLERS FOR POLYOLEFIN AUTOMOTIVE FOAM SUBSTITUTION

NEW TECHNOLOGY	PO FOAM CHALLENGER	INCUMBENT	SHAPE TYPE	EXAMPLE APPLICATION
WATER BLOWN TPE	TPV	EPDM SPONGE	PROFILE	BODY SEALS
-RAD XLPO -HMS PP -MICROCELL	XLPO	SKIVED PU	THIN SHEET	SKIN/FOAM LAMINATES
EXTRUDED THICK SHEET	STRANDFOAM® (DOW)	PU FOAMS	THICK SHEET	HEADLINER EAs
ACOUSTIC BEAD FOAM	JSPI	PU FOAMS	MOLDED (STEAM)	FLOOR SYSTEMS
IN-MOLD SKIN/FOAM LAMINATION	EPP	-PU SKIVED -PAPER	MOLDED (STEAM)	SUN VISORS
-MULTI DENSITY -PART INTEGRATE	EPP BEAD FOAMS	-PU FOAM -CELLULOSIC -FIBERS	MOLDED (STEAM)	DT PANELS, HEADLINER EAs
METALLO PO	SHEET FOAM	SKIVED PU	SHEET	GASKETS, SKIN/FOAM LAM
TEXTILE/PO FOAM LAMINATES	XLPO	SKIVED PU	SHEET	DOOR TRIM MEDALLIONS

SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

EXHIBIT 10

DIFFERENCES BETWEEN EUROPE AND N. AMERICAN AUTOMOTIVE FOAM MARKETS AND DRIVING FORCES

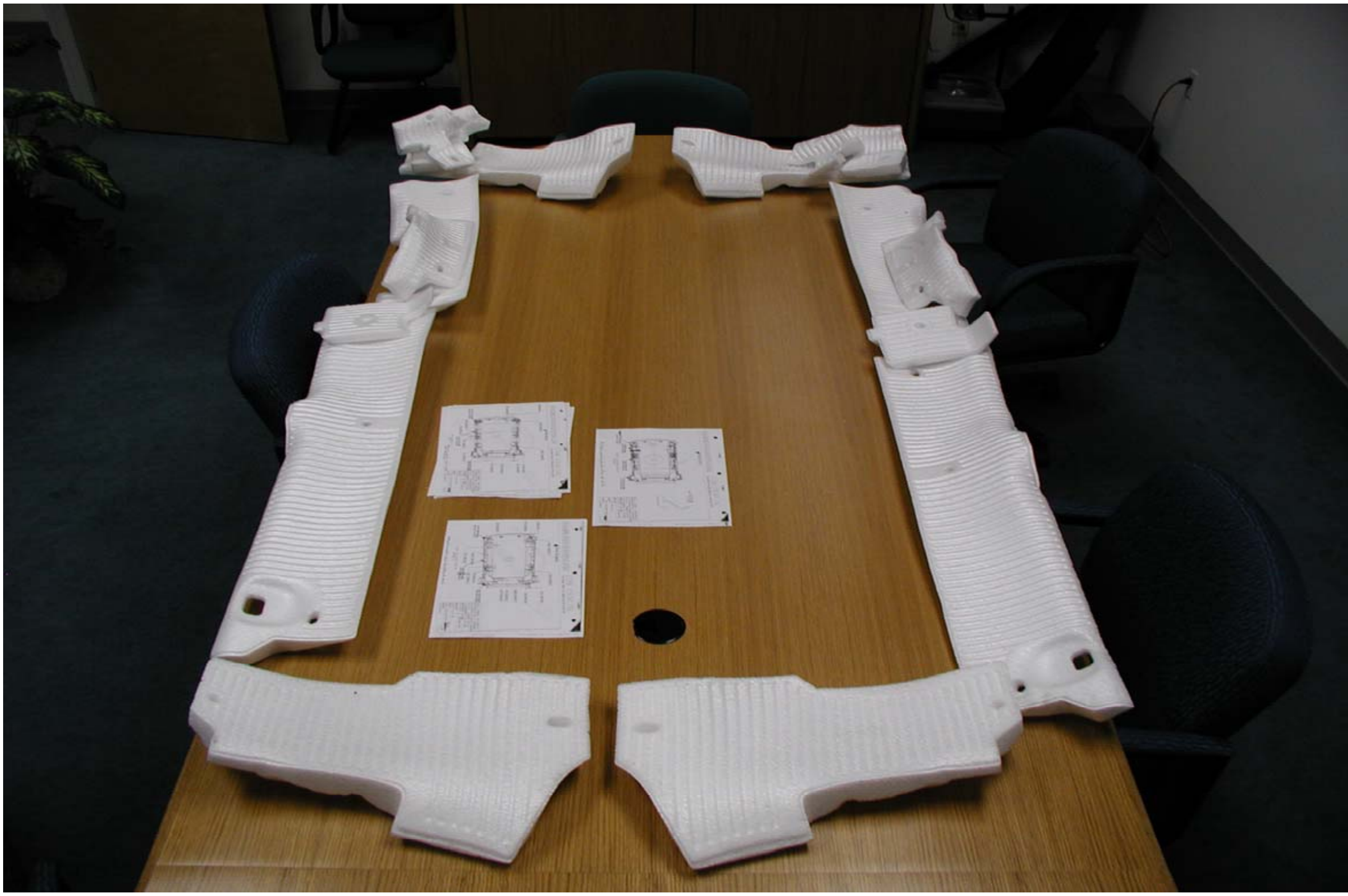
FACTOR/SECTOR	EUROPE	N. AMERICA
IP AND DT SKIN/FOAM LAMINATES	HIGHER USE OF XLPO SHEET FOAMS	WILL GROW WITH NEGATIVE THERMOFORMING
BUMPER SYSTEMS	EPP BEAD FOAM EAs STARTING DRIVEN BY PEDESTRIAN SAFETY	ALREADY HIGH SECTOR PENETRATION
SHODDY IN FLOOR ACOUSTIC BARRIERS	20% SHARE	50% SHARE (DECLINING)
SUN VISORS	EPP FOAMS	INJECTION MOLDED
LOAD FLOORS	SLOWER START	RIGID SKIN/EPP FOAM LAMINATES STARTING
INTERIOR EA REQUIREMENTS	LOWER (NOT MAJOR DRIVER YET)	MAJOR FOAM DRIVER FOR HEADLINER/DOOR TRIM PANELS
TPE BODY SEALS (FOAM)	RAPID GROWTH EXPECTED	
INTEGRAL SKIN/FOAM PVC	USED FOR IP AND DT	SOME USE IN DT. CHALLENGED BY TPO/XLPO LAMINATES
INTERIOR VOC STANDARDS	INCREASING	NOT A FACTOR YET
ZERO SMELL INTERIOR	MATERIALS PERFORMANCE CRITERION	STARTING AS EVALUATION CRITERION
RECYCLING	SIGNIFICANT DRIVER	LESS IMPORTANT
ELV LEGISLATION	IN PLACE	NONE YET
LD-RIM IN DT PANELS	VERY MINOR	SIGNIFICANT USE
REQUIREMENT FOR PROCESS COST SAVINGS	MAJOR MATERIAL SUBSTITUTION DRIVER	

SOURCE: ROBERT ELLER ASSOCIATES, INC.
SOFT TRIM MULTICLIENT STUDY, 2003

EXHIBIT 11
EPP FOAM USE ON DOOR MODULE

SOURCE: TARACELL

EXHIBIT 12
EXAMPLE OF EPP USAGE AS HEADLINER COUNTER MEASURE (2002 PT CRUISER)



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

EXHIBIT 13
PU FOAM TRUNK LINER (2002 BMW MINI COOPER S)

SUPPLIER: RIETER
PHOTO SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003