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TPEs . . . FINDING VALUE THROUGH MATERIALS AND PROCESS INNOVATION

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Presented by:
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Abstract -- TPEs continue their growth, but pricing pressures from a deflationary global economy, global competition, and intensified intra-TPE competition at both the resin and compound level have and will continue to impact profitability. This paper examines how TPEs can build value via both materials substitution and process technology innovation in automotive and non-automotive applications.

The presentation is based on:

- Recent research
- REA's recently completed auto interior soft trim study(1)
- Our global TPE multiclient study(2)

This paper will examine:

- Current market and economic conditions affecting the TPE industry
- The role of Asian participation in TPE markets
- The relationship between current macroeconomic conditions in N. America and Europe and the implementation of new TPE material and process technologies
- The implications of the penetration of TPEs into developing automotive applications
- Opportunities for value-added TPEs
- How TPE industry structure and path to market are changing.

TPE Families -- Some of the impacts of new technologies on the families of TPEs are illustrated in Exhibit 1.

TPEs and the Economy -- TPE growth rates have been less affected by the extended recessionary global economy than other plastics and elastomers. The SBC and TPV-type TPEs, for example, are still experiencing double-digit growth. Profitability, however, has been impacted by severe price pressures, particularly in the automotive sector, which typically accounts for about 40% of TPE demand and by increased competitive intensity on the supply-side of the TPE market.

Price Erosion -- TPE resin and compound prices have eroded over the past several years for a variety of reasons:

- The entry by Asian TPE producers into European and N. American markets
- Pricing for molded parts based on global (especially Asian) sourcing
- The rapid increase in the number of TPE compounders
- The demonstrated ability of lower priced TPEs to take share from higher priced TPEs
- The entry by metallocene-catalyzed polyolefins and reactor-based compounds
- The proliferation of TPV compounding technology.

Price/Value Gain Opportunities -- In addition to intra-TPE competition, TPEs compete with:

- PVC compounds (a formidable, low priced competitor, gaining or retaining share in some markets, e.g., window glazing, auto interior skins)
- ETPs (e.g., in bumper fascia)
- Thermoset rubbers (on a systems replacement basis; rarely on a direct 1:1 drop-in basis).

TPEs are used alone as a molded part, but a substantial portion of the applications is in combination with other materials such as:

- Glass (e.g., in automotive and non-automotive glazing seals)
- Fibers (e.g., in reinforced hose, belting, and [recently] coated fabrics)
- Other TPEs (e.g., in multi-TPE co-processed assemblies)
- Other resin families (e.g., in rigid/flexible assemblies, soft touch parts, gasketing applications)
- Metals (e.g., in sealing applications).

This participation in a system (and the associated potential for cost savings) is a major driver for adding (or retaining) value in new TPE applications. The association with other materials during fabrication has resulted in a focus on research to improve rheological characteristics and surface properties for adhesion.

THE ROLE OF AUTOMOTIVE APPLICATIONS IN TPE VALUE/GROWTH OPPORTUNITIES

Why is Automotive Important? -- Apart from the current high market share and rapid growth potential represented by automotive applications, the auto market is a key driver for new TPE technologies. The new technologies developed for automotive applications are often adapted in other sectors. (Some examples of this technology migration are: 3D blow molding, foam extrusion, and coated fabrics.)

Automotive Economics/Industry Structure Effects on TPEs -- The transfer of economic pressures from automotive OEMs to their materials and module suppliers is driving a shift in the position of TPEs in the value chain and providing a major incentive for TPE growth and profitability, as illustrated in Exhibit 2. The current automotive economic/technology interface can be summarized as follows:

- Auto OEMs are operating in an extended, global recessionary economy.
- Rapid growth of global parts sourcing (China usually has the lowest prices).
- Vehicle prices have continued to decline (especially since the price wars initiated after Sept. 11), creating severe downward price pressure on suppliers at all levels.
- Resin price increases (starting in late 2002) combined with vehicle price decreases have created a squeeze on Tier 1 supplier profits, which in turn provide incentive for TPE materials and process innovations capable of adding value while providing cost savings.
- Tier 1 consolidation has created a substantial increase in purchase power (pressuring prices downward) as well as incentives for in-house TPE compound manufacture (e.g., for body seals, acoustic damping compounds, and skins formulations).
- The continuing vehicle market share loss by domestic OEMs to non-domestic competition is stimulating the entry of Japanese and European compound and process technology. (Some examples of Japanese and European TPE technology contributions are shown in Exhibit 6.)
- The relatively higher profitability of non-domestic OEMs sustains a higher level of product and process development (see Exhibit 3).
- In order to defend sales in the highly profitable light truck sector, automakers are willing to spend money for lightweighting (an approach particularly well suited to the use of TPEs) as illustrated in Exhibit 5.
- High volume (sometimes global) multi-vehicle platforms have increased (see Exhibit 7), raising the stakes for successful participation.

OEM Profitability -- In the current economic environment, many automotive OEMs are unprofitable as illustrated in Exhibit 3. The higher profitability of the Japanese OEMs allows greater investment in new materials technology, which has translated to higher

value TPEs and earlier introduction of TPE solutions (TPV body seals in Japan, for example).

Automotive Material Substitution Driving Forces -- The economic and technical driving forces for automotive materials and process substitution favor the use of TPEs as illustrated in Exhibit 4.

Role of Lightweighting in Automotive Applications -- Light weight solutions have always been an automotive materials substitution driving force. Low fuel prices have made weight savings a lower priority in N. America than in Europe and Japan. The recent increased emphasis on fuel economy in (and the pressures to re-examine CAFE legislation) in order to defend the profitability of SUVs and light trucks in the N. American market will make weight savings a major driving force for TPE material and process substitution as automakers assign increased value per kg of vehicle weight saved. As illustrated in Exhibit 5, the structuring of CAFE values is influenced by the political process.

Auto Interior Soft Trim and the Role of Two-shot Molding -- Auto interiors are emerging as a major growth opportunity in automotive TPE applications (see References 1 and 2). Key among these interior growth applications are skins, skin/foam laminates, coated fabrics, airbag doors, and non-carpet flooring. Substitution of TPO skins (initially vacuum formed) started in Europe and has spread to N. America and Japan.

Most interior soft trim assemblies are made by relatively inefficient multi-step processes (skin preform, substrate molding, back-molding). Using two-shot molding technology developed for grips, knobs, and toothbrushes, molding machine makers have developed technology for molding large area skin/substrate parts (door trim panels, for example) in a single, multi-shot operation which:

- Saves process steps
- Reduces trimming operations
- Reduces scrap (when running to specification)
- Eliminates adhesives
- (Possibly) allows the molding of integral skin/foam surfaces (thereby permitting further cost savings)
- Improves grain formation (compared to vacuum formed skins).

Initial large area applications for two-shot molding of large parts with TPE surfaces are likely to be in door trim panels and rocker panels with the potential for extension to instrument panels.

Coated Fabrics -- In combination with leather, PVC coated fabrics are widely used for automotive seating. Coated fabrics represent a large potential market for TPO and some SBC-type TPE competitors. Recent compound developments and receptivity by European and Japanese auto OEMs suggest that penetration of the coated fabrics sector

by both styrenic and olefinic TPE coated fabrics will begin in the next model year in seating and security shades. The development of RF sealing methods for TPOs will facilitate this penetration.

The Role of Foams -- Foaming brings value to TPEs as a result of softness, energy absorption (depending on thickness and foam structure), acoustic properties, and the potential for cost savings when they are integral with the skin or other surface material (e.g., textiles). The rheological properties of TPEs can be adjusted to accommodate the foaming process. The combination of foaming with two-shot molding offers the potential for both cost savings and the addition of value to the constructions in which they are used. Polyolefin foam sheets are being combined with textiles (e.g., the door trim medallion of the Renault Laguna II has a polyester textile/polyolefin foam sheet laminate). Thus far, the potential added value of TPE foams has been under-exploited.

Price Swings -- The post-9/11 period has seen severe raw material price swings. (EPDM prices have remained relatively unaffected.) In mid-2003 prices for most plastics, rubber, and TPEs have recovered from the mid-2002 trough, but raw material costs are squeezing profits for TPE producers, and TPE prices are squeezing profits for molders attempting to compete in the severely price pressured automotive sector. The low prices for thermoset rubbers in the trough made TPE competition more difficult in those applications in which direct substitution rather than systems cost savings was sought. (See examples of the TPE competitive interface with rubber in Exhibit 8.)

TPE Industry Structure Shift -- The structure of the TPE supplier industry is changing:

- Asian imports (primarily from China) are setting global market prices for parts (thereby attracting compounders and TPE suppliers).
- Financial groups have entered the TPE industry (e.g., at Kraton, Noveon, and Eliokem).
- TPE concentrates with good rheological properties are offered to specialty compounders and major fabricators.
- Compounding technology has proliferated to both compounders and fabricators.
- Some major fabricator customers back integrate to TPE production.
- In-line compounding/fabrication is showing signs of becoming feasible.
- TPE compounders form partnerships with customers (AES/DS Chemie, SEP/TRS).
- Major TPE compounders broaden their product line (e.g., DSM/GLS joint venture).
- Co-processing (injection molding, blow molding, extrusion) encourages resin suppliers to provide package offerings.

The Asian Challenge -- The emergence of Asian manufacturing and associated TPE supply are changing the global footprint of TPE markets and setting the pricing floor:

- Large populations (especially in China with 1.3 billion people) provide high growth domestic markets.
- Raw material costs are relatively low.

- Parts manufacturing costs are low:

  Labor rates are typically $0.30-0.50/hr.
  Many social costs are provided by the government.
  Electricity costs are at least 30% lower than in Europe and N. America.
  Taxes are relatively low.
  The environmental and regulatory burdens are lower.
  Tax benefits are available.
  Quality is improving to meet western standards.

- The recent strong dollar has encouraged imports of TPEs and (more importantly) molded parts. Ford, for example, will increase Chinese parts imports from $1 billion in 2002 to $10 billion in 2010. An undervalued Chinese currency (fixed at low rates) in particular has encouraged imports from that area in the last two years. The U.S. trade imbalance with China is approximately $100 billion/year.
- Japanese TPE suppliers have entered the N. American market (and captured significant shares, especially in the TPO, SEBS, and TPV sectors) and are being followed by Asian suppliers from Korea and Taiwan (e.g., Taiwan Synthetic Rubber).

Identifying Value and Growth Opportunities -- Some of the process/property combinations that provide opportunities for value and growth in TPEs are:

- Direct compounding/fabrication of TPE parts
- Two-shot molding of large area parts
- Improved acoustic/damping properties (potential for isoprene-based SBCs)
- Foaming for energy absorption, control of noise, vibration, and harshness
- Combining foaming with extruded and molded parts
- Extending the property range into more profitable sectors (improved compression set properties, oil resistance, adhesion, scratch/mar resistance)
- The masterbatch approach (which allows fabricators to tailor formulations and avoid paying for compounding of commodity resins)
- TPE films in in-mold decoration applications (ionomer, TPU)
- Coated fabrics
- Non-carpet flooring (currently used on the Ford Transit, Honda Element, Ford F-150 truck)
- Acoustic barrier sandwiches in flooring.

SUMMARY

The automotive sector continues to dominate TPE markets and is a major source of materials and process technology innovation driven by intense price pressures and recently by global sourcing policies, which set a pricing floor for molded parts. The substitution of TPEs (especially TPVs) for EPDM body seals will provide major stimulus to the growth of the TPV sector and the development of improved extrusion and foaming technology.

The differences in TPE fabrication and materials technologies between Japan and Europe and N. America are converging rapidly, driven by high volume global platforms, the increasingly porous boundaries to the transfer of technology, and the strong incentives to replace the current inefficient automotive constructions.

The path to market for TPEs (especially TPV) is changing as:

- Compounding technology proliferates
- The use of concentrates becomes more common
- The potential for direct compounding/fabrication is more fully explored by major Tier 1 fabricators
- Asian TPE producers and parts suppliers gain share.

The use of TPEs presents opportunities for systems cost savings and added value materials combinations via both materials and processing technologies. Most of these opportunities are under-exploited.

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2. 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)

3. TPE TOPCON (December 2002), R. Eller presentation

4. "North American Instrument Panel Compact Disc-- 2003," REA's Photo/Supplier Database

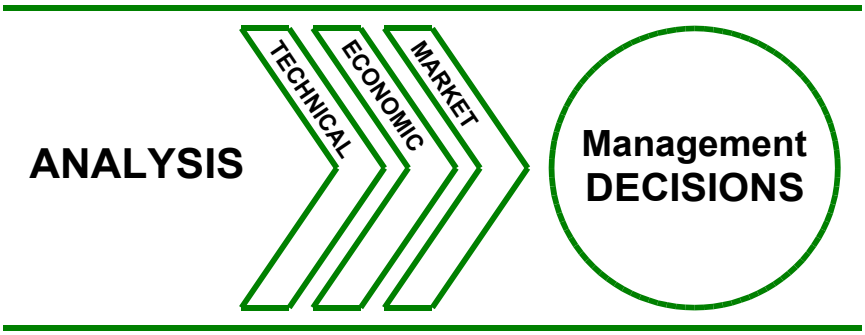
5. "Olefinic and Styrenic TPEs: Markets, Economics, Intermaterials Competition, and the Role of Plastomers," RAPRA TPE 2001, Amsterdam, June 18, 2001; Robert Eller

6. "Matériaux d'habitacle Automobile et Approche Sensorielle," Comfort Automobile et Ferroviaire; Le Mans, France; November 15, 2000; D. Nesa; S. Couderic; S. Crochmore.

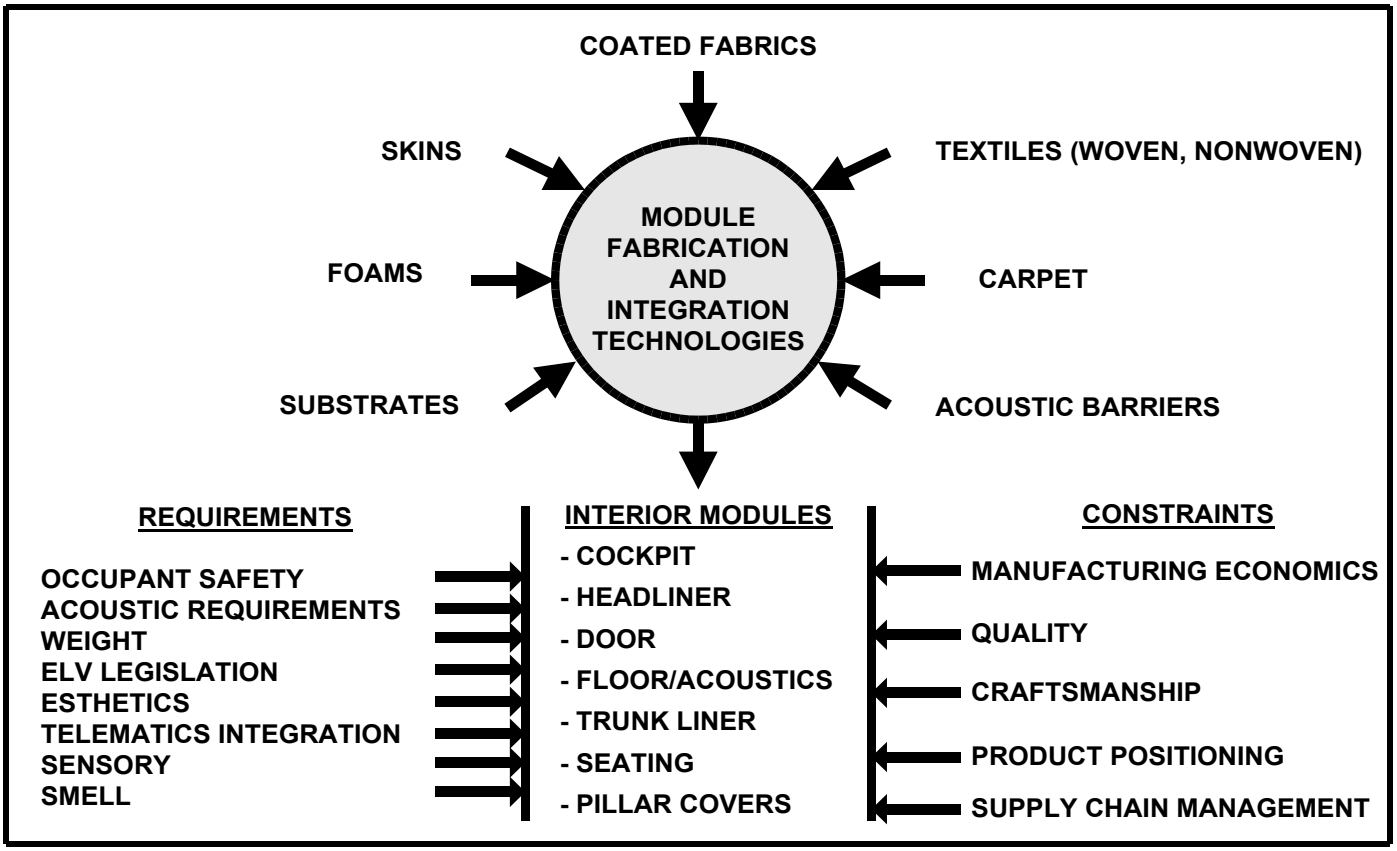
7. "Acoustic Barriers-Material Substitution and Industry Structure Drivers," *Automotive and Transportation Interiors*, November 1999, p. 46; R. Eller

GLOSSARY OF ABBREVIATIONS

CAFE	-	CORPORATE AVERAGE FUEL ECONOMY
COPA	-	COPOLYAMIDE
COPE	-	COPOLYESTER TYPE TPEs
c-TPO	-	COMMODITY TPO (E.G., BUMPER FASCIA)
ESI	-	ETHYLENE STYRENE INTERPOLYMER (E.G., DOW'S INDEX)
EV	-	ENTERPRISE VALUE
f-TPV	-	FULLY CROSSLINKED TPV
p-TPV	-	PARTIALLY CROSSLINKED TPV
IC	-	INVESTED CAPITAL
IP	-	INSTRUMENT PANEL
m-PO	-	METALLOCENE POLYOLEFIN
MID	-	MOLDED-IN DECORATION
NVH	-	NOISE, VIBRATION, HARSHNESS (PERFORMANCE DRIVER FOR INTERIORS)
OEM	-	ORIGINAL EQUIPMENT MANUFACTURER (E.G., THE AUTOMAKER)
r-TPV	-	RECYCLATE-BASED TPV
ROIC	-	RETURN ON INVESTED CAPITAL
SBC	-	STYRENE BLOCK COPOLYMER TPEs (SEBS, SBC)
SBS	-	STYRENE-BUTADIENE-STYRENE TYPE TPE
SEBS	-	STYRENE-ETHYLENE-BUTADIENE-STYRENE TPEs
s-TPO	-	SPECIALTY TPO (E.G., MEDICAL, AUTO BODY SIDE MOLDINGS, BUILDING/CONSTRUCTION)
TF	-	THERMOFORMING
TPV	-	THERMOPLASTIC VULCANIZATE
TSR	-	THERMOSET RUBBER
WACC	-	WEIGHTED AVERAGE COST OF CAPITAL



Automotive Interior Soft Trim:
Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers



Prospectus for a Global Multiclient Industry Analysis **July 2001**

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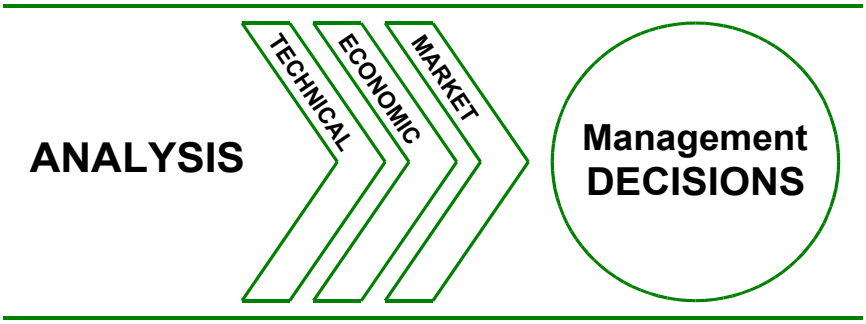
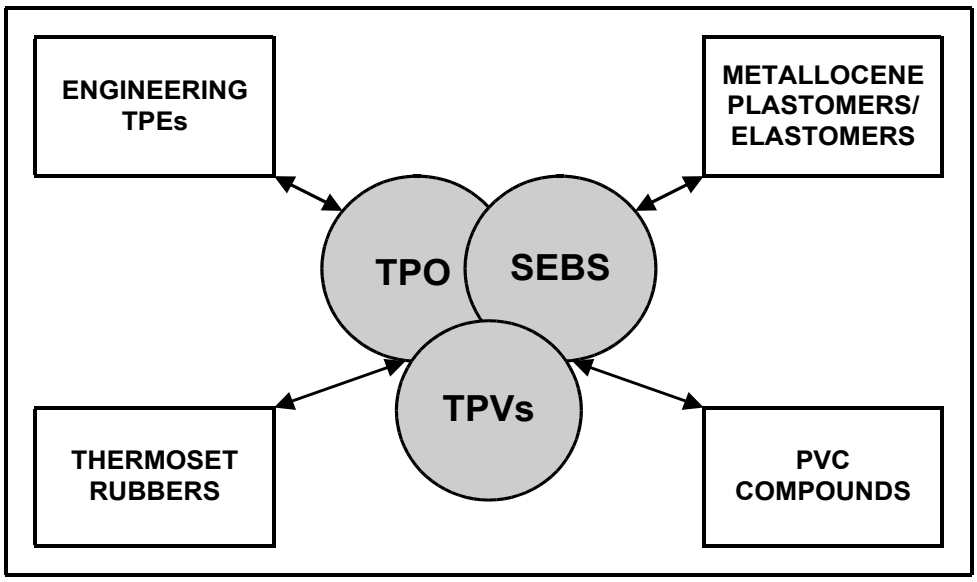


SEBS, TPV, and TPO-type Thermoplastic Elastomers ... Markets, Economics, Technology, Intermaterials Competition, and the Role of Metallocene Resins



Prospectus for a Euro/US/Japan Multiclient Industry Analysis

January 2000

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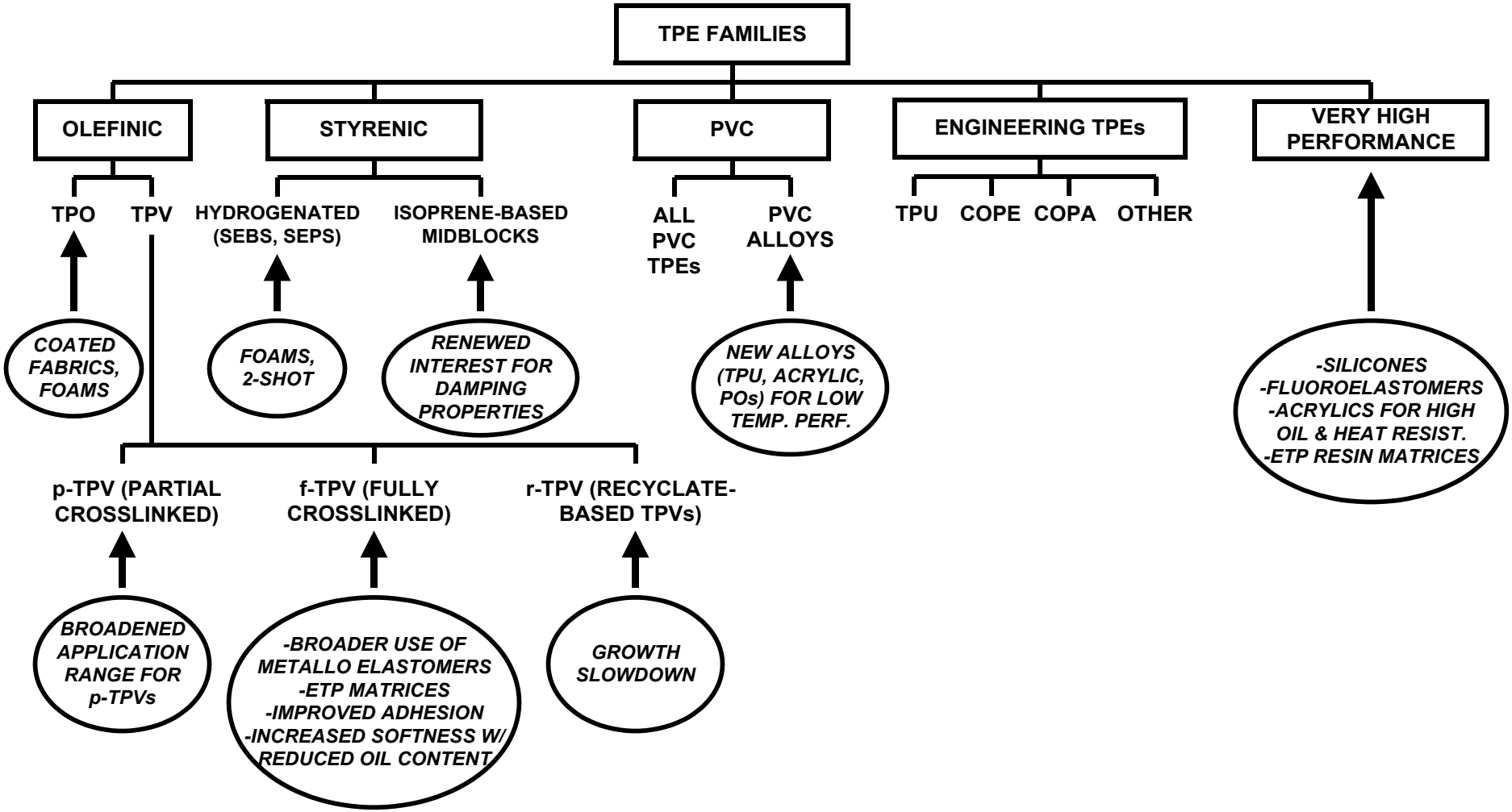
EXHIBIT 1

GROWTH AND VALUE OPPORTUNITIES IN THE TPE FAMILIES



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

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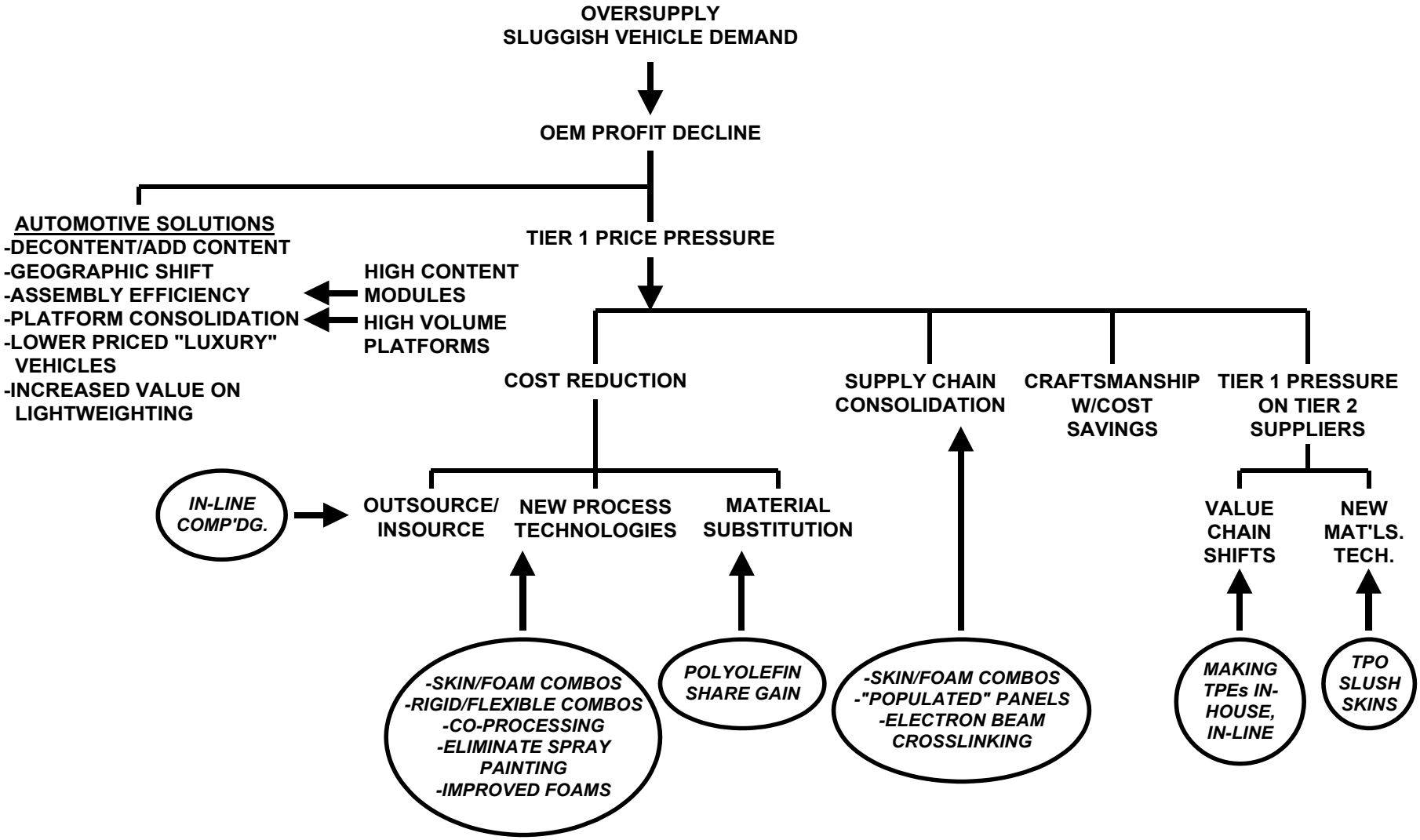
EXHIBIT 2

AUTOMOTIVE OEM/SUPPLIER DYNAMICS AND EFFECT ON TPEs



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

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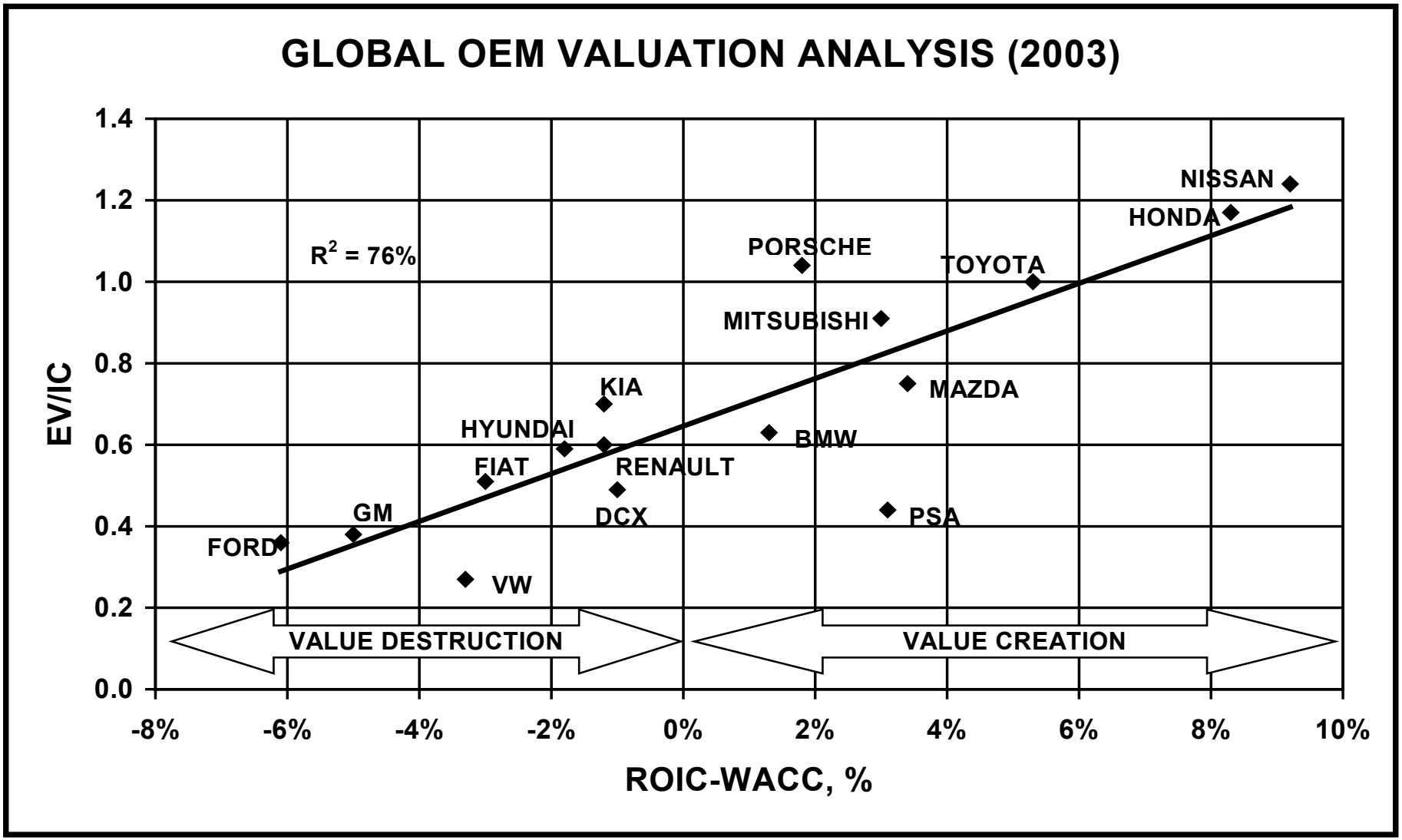
EXHIBIT 3



SOURCE: GOLDMAN SACHS

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EXHIBIT 4

TPEs' ABILITY TO MEET AUTOMOTIVE MATERIAL/PROCESS REQUIREMENTS

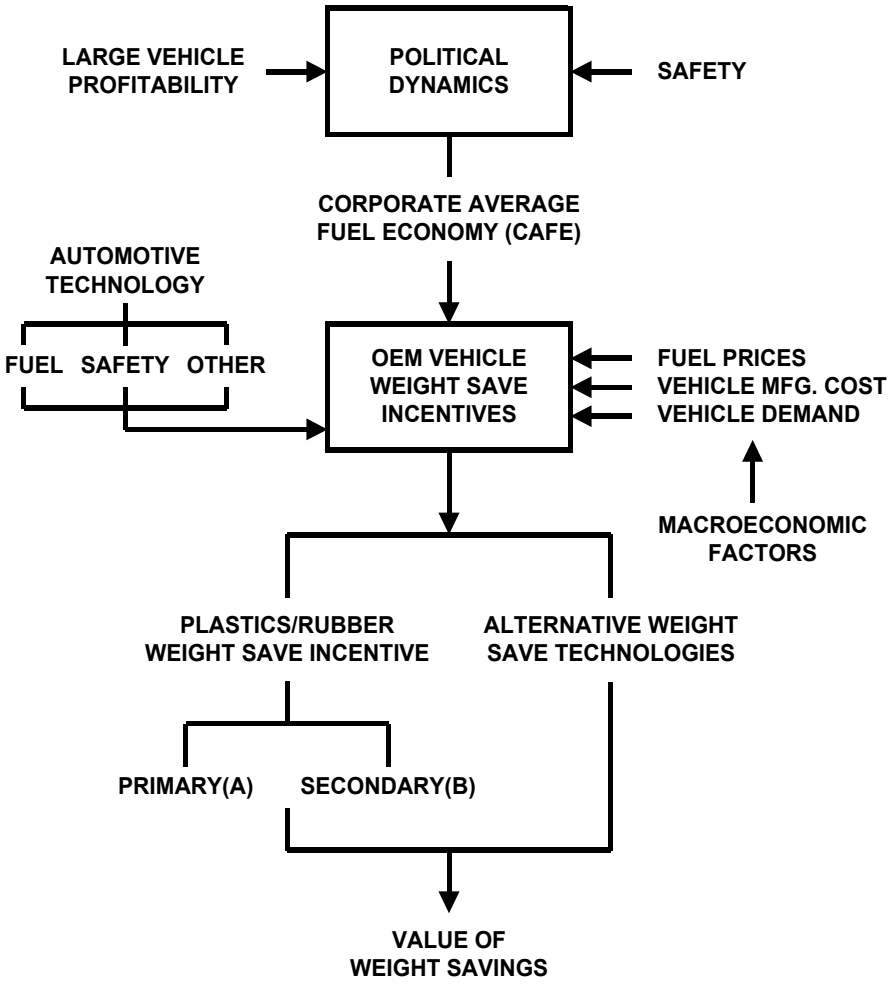
SYSTEMS COST SAVINGS	TPE IMPLICATIONS/EXAMPLES
SYSTEMS COST SAVINGS	-RIGID/FLEXIBLE COMBINATIONS -TPE BODY SEALS -TWO-SHOT MOLDING OF LARGE PARTS
WEIGHT SAVINGS	-INCREASED TPE FOAM USE -SUBSTITUTE FOAMS FOR HEAVY LAYER
SOFT TOUCH	-TWO-SHOT MOLDING (ESPECIALLY LARGE PARTS) -COEXTRUSION OF SOFT TOUCH SURFACED TPEs
LOW GLOSS	-A TPE BENEFIT FOR SEBS
OIL RESISTANCE	-IMPROVED LOW OIL TPEs (METALLO INGREDIENTS)
INVISIBLE AIRBAG DOORS	-MAJOR DRIVER FOR p-TPV INSTRUMENT PANEL SKINS AND (RECENTLY) PVC ALLOY SKINS
ODOR-FREE INTERIORS	-PLASTICIZER REDUCTION -SUBSTITUTE OLEFINS FOR OTHER FAMILIES
ELIMINATION OF COATINGS	-IMPROVED SCRATCH/MAR TPE GRADES -IN-MOLD DECORATION(A) -INCREASED COEXTRUSION
BODY COLOR MATCH	-EPDM REPLACEMENT IN BODY SEALS
MOLDED-IN COLOR	-TPEs WITH IMPROVED COLOR CONTROL -LOWER FILLER LEVELS
IMPROVED NOISE, VIBRATION, HARSHNESS CONTROL	-TPEs WITH INTEGRAL FOAM LAYERS -ISOPRENE-BASED GRADES
ACOUSTIC PERFORMANCE	-ISOPRENE-BASED GRADES -CONTROLLED DENSITY FOAMS -ELIMNATION OF HEAVY LAYER CONSTRUCTIONS
ENERGY ABSORPTION (OCCUPANT SAFETY)	-ON-BOARD FOAM CONSTRUCTIONS
RECYCLABILITY	-TPE ROLE IN ALL-POLYOLEFIN CONSTRUCTIONS

NOTE:
(A) SEE SKETCH OF TPE VALUE-ADDED DECORATION IN REFERENCE 3

SOURCE: ROBERT ELLER ASSOCIATES, INC., SOFT TRIM MULTICLIENT (REF. 1)

EXHIBIT 5

FACTORS AFFECTING VALUE OF AUTOMOTIVE WEIGHT SAVINGS (EXAMPLE ONLY)



NOTES:
(A) E.G., VIA MATERIAL SUBSTITUTION
(B) E.G., FROM PARTS CONSOLIDATION

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003
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EXHIBIT 6

EXAMPLES OF EUROPEAN/JAPANESE TPE TECHNOLOGIES

TPE TECHNOLOGY	SOURCE	NOTE
TPO SLUSH MOLDING COMPOUND	J(A)	-PENETRATING EUROPE, JAPAN, N. AMERICA IP SKINS
SEBS/TPU ALLOY SLUSH MOLDING COMPOUND	J	
TOYOTA TSOP TECHNOLOGY	J	-WIDELY USED AND LICENSED -SELLING AT 2X CONVENTIONAL COMPOUNDS
TPO SKINS	J	-FIRST TPO DROP-IN VAC FORMED SKIN
TPO COATED FABRICS	E	-FIRST COMMERCIAL APPLICATIONS IN EUROPE
REPLACEMENT FOR DOW'S ESI	J	-FROM ASAHI KASEI
ISOPRENE-BASED MIDBLOCK SBCs	J	-FOR VIBRATION DAMPING
CROSSLINKED PVC COMPOUNDS	J	
SOFT TOUCH COEXTRUDED SHEET	E	
ALL-PO CARPET SYSTEM	E	
TPV, SEBS IN GLAZING SEALS	J, E	
SEBS FOAMS	E	-FROM KRAIBURG
TPO BUMPER FASCIA	J, E	
SEBS OVERMOLDED ON ABS	E	-FOR ROCKER PANELS
SEBS/PP IN GLAZING FRAMES	E	-BMW 5 SERIES REAR QUARTER

NOTE:

(A) FROM SUMITOMO

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

EXHIBIT 7

GROWTH OF HIGH VOLUME VEHICLE PLATFORMS

OEM	PLATFORM	MODELS	MM UNITS	NOTE
VW	PQ35	GOLF	2.4	PVC SLUSH IP SKINS
	PQ24/25	POLO	1.2	
FORD	F-SERIES	LT. TRUCKS	1.1	NON-CARPET FLOORING FOR 40% OF FLEET
	MAZDA 6	FUTURA FORD 500 FREESTYLE	0.8	
	C1	FIESTA	1.6	
GM	EPSILON		1.0	ENCOURAGES EUROPEAN TIER 1 ENTRY
	GMT 800/900		1.5	
TOYOTA		COROLLA	1.5	
PSA	PFI	206	1.7	

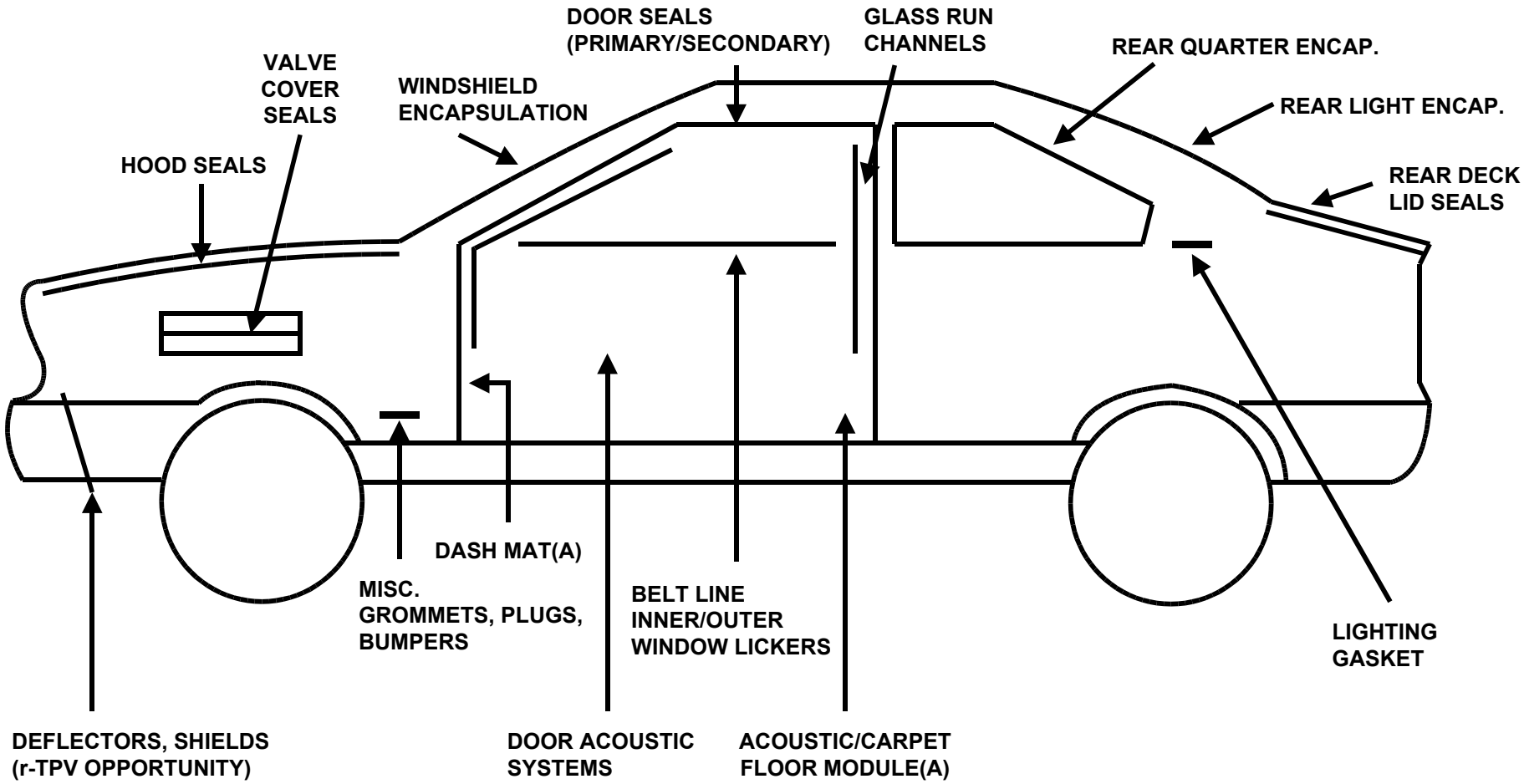
NOTE:

HIGH VOLUME PLATFORM PENETRATION ALLOWS MAJOR GAINS/LOSSES AND GLOBAL PRESENCE FOR MATERIALS SUPPLIERS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

EXHIBIT 8

TPE/RUBBER COMPETITIVE INTERFACE IN AUTO APPLICATIONS



NOTE: (A) ACOUSTIC/FOAM OPPORTUNITY

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

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EXHIBIT 9

TPE CHALLENGERS TO MAJOR AUTOMOTIVE RUBBER AND PVC INCUMBENTS

APPLICATION	TPE CHALLENGER							
	PVC	TPV	SEBS	TPO	TPU	COPE	r-TPV	OTHER
ACOUSTIC BARRIERS			X					
AIRBAG DOORS			X	X				
BELTING		X			X	X		
BODY SEALS		X	X					
BOOTS/BELLOWS		X				X		
COATED FABRIC				X	?			
DAMPER MOUNTS		X	X					
ELECTRIC		X	X					
FLOOR MATS				X				
FUEL SYSTEMS								X
GLAZING SEALS	X	X	X					
HIGH PERFORMANCE GASKETS								X
INTERIOR SKINS		X		X	X			
NON-CARPET FLOOR				X				
UNDERHOOD DEFLECTORS							X	X
IN-MOLD DECORATION								X

SOURCE: ROBERT ELLER ASSOCIATES TPE AND SOFT TRIM MULTICLIENTS (References 1 and 2)