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AUTOMOTIVE INTERIOR TECHNOLOGY TRENDS AND THE IMPACT OF ENVIRONMENT/RECYCLING CONCERNS

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Abstract –The imperatives of cost reduction and End of Life Vehicle (ELV) legislation in Europe are encouraging the use of mono-materials construction in automotive interior soft trim and placing increased emphasis on recyclability of automotive plastics and rubber components. This paper will review these trends and their impact on materials and processes for North American and European automotive interior soft trim.

The presentation is based on:

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

ENVIRONMENTAL/REGULATORY/LEGISLATIVE IMPACTS OF ELV LEGISLATION

ELV Summary -- The only current or emerging legislative/regulatory issue that directly or indirectly impacts interior trim is the European Union End of Life Vehicle (ELV) Directive. There is no restriction on polymer selection in the ELV Directive. All polymers, including PVC, may be selected based upon cost/performance criteria. The potential impact on interior trim is linked to future "ease" of recycling as required by the ELV Directive. Recovery & recycling of Auto Shredder Residue (ASR) is still faced with several problems that remain to be resolved.

End-of-Life Vehicles (ELV) Directive 2000/53/EC -- The deadline for national transposition of EU legislation requiring car makers to take financial responsibility for dismantling and recycling end-of-life vehicles (ELVs) was on April 21, 2002. Some EU member countries have not yet done so as of yet.

The delay is primarily linked to the financial responsibility/liability requirements. Other issues blamed for the delays have been the retroactivity of the directive, which conflicts with some member states' constitutional requirements. There are, furthermore, a number of minor but important technical and infrastructure issues such as monitoring of the directive's recovery, re-use, and recycling targets. The delay and dispute has resulted in legal pressure on some EU countries.

A detailed analysis of the ELV legislation is given in Reference 1.

For automotive interiors, the ELV directive could, hypothetically, have an impact/influence in three general areas:

- *Recycling* in general, and more specifically *recovery and/or recycling* of ASR;

- Restriction of the use of *hazardous substances* (Directive 67/548/EEC) where possibly a polymer-formulation may contain a hazardous substance (stabilizer, catalyst, pigment, etc.)

- Some national (and EU) regulations require *Compulsory Dismantling* of certain parts – eventually PU/PVC foam seats, instrument panels, etc.

The ELV directive is based upon the EU Environmental Policy to reduce waste. Indirectly, it will also be impacted by the European landfill regulations. The ELV targets are:

ELV TARGETS/DATES

TARGET	DATE
Reuse & recovery of min. 85% by weight Reuse & recycling of min. 80% by weight	January 2005
Reuse & recycling of min. 95% by weight Reuse & recycling of min. 85% by weight	January 2015

The ELV implementation timeline is as follows:

ELV IMPLEMENTATION TIMELINE

ACTION	DATE	NOTE
Transposition into national law	June '02	Not passed in some EU countries
Free take-back of new cars	July '02	
Elimination of Pb, Hg, Cd, Cr6+	July '03	No effect on interiors
Re-examination of '15 quotas	Dec. '05	
Implementation of recycling quota	Jan. '06	
Free take-back of all cars	Jan. '07	
Revision of quotas	Jan. '15	

For clarity, some definitions are given below:

a. *Recyclable* – a material that is theoretically possible to recycle:

   - Mechanically -- back to the polymer
   - Chemically -- back to the monomer
   - Energy -- to recover the caloric value

b. *Recycled* – is the material (% or quantity) that is actually recovered and recycled by either of the above methods (also referred to as *recycling rate)*.

c. *Recyclate* – refers to the resin that has been produced by mechanical recycling and is marketed as "recyclate." The cost to recycle may vary depending upon the process. Economic feasibility of recycling will be determined in part by the (fluctuating) price of virgin resins

PVC Related Impacts: The "average" car in Europe currently uses 16 kg of PVC for all applications. The volume has remained more or less the same for the last three years and will increase in the next several years, particularly in slush molded skins and glazing seals.

The plasticizers used in PVC vary by application and specification. The most commonly used plasticizers are phthalates. EU has made risk assessments of the phthalates, and there is still debate over some of the issues and allegations with regard to DEHP. The allegations are refuted by the plasticizer industry, but it is expected that there is sufficient debate to lead to specifiers' substituting other plasticizers for DEHP. Several PVC formulations with alternative plasticizers are offered and used (e.g., polymeric plasticizers, citrates, etc.). Some examples of PVC formulation improvement are given below:

IMPROVED EUROPEAN PVC FORMULATIONS FOR AUTO INTERIOR SKINS

PROPERTY	1990s	TODAY
Fogging	> 5 mg	< 1.5 mg
Emissions	50 ppm	< 10 ppm
Low temperature resistance	-30ºC	-40ºC
Light maintenance DIN 75202	1 cycle	5 cycles

Zero V.O.C. (Volatile Organic Compounds) in the Interior -- At a VDI working session in May 2002, the potential standards for V.O.C levels were explored. The catalysts used for PU foam polymerization can affect V.O.C. Numerous other sources of volatiles are found in auto interiors, and the V.O. C. target levels may well provide a basis for discrimination between materials candidates. The specific target levels are uncertain, but may reach as low as 10 ppm/24 hrs. These V.O.C. requirements are likely to shift to the NAFTA fleet. The debate around formaldehyde in relation to V.O.C., etc. will most likely increase and has already had an impact on the recycled fiber materials used in floor/acoustic constructions.

Occupant Safety-- Europe will probably adopt the U.S. HIC(d) requirements. This will affect the choice and quantity of foams used for EA energy absorbers in headliners and door trim panels. An increase in the use of steam chest molded EA blocks in these applications has occurred. The anticipated increase in usage of EPP will lead to:

- Incorporation of EPP into the structure of modules such as door trim panels, instrument panel uppers, and headliners
- Increased use of polyolefin textiles (a priority target of several European OEMs).

Acoustic Performance -- Although not legislated, the requirement for reducing interior noise levels (while at the same time reducing weight) is a major driving force for material and process substitution in acoustics modules (e.g. dash mat, passenger compartment, flooring, trunk floor and headliner).

Heavy Metals -- The ban on the use of lead, mercury, cadmium, and hexavalent chromium is part of the ELV Directive. There are twenty exemptions. The key impact will be on batteries, wheel balance, etc. Heavy metals have already been removed from PVC skin formulations.

Environmental Marketing -- Eco-marketing has focused on the reduction of carbon dioxide via fuel economy and shifted away from a focus on interior materials. Environmental issues remain a relatively low priority, particularly in the U.S. where fuel economy performance has steadily dropped (see Exhibit 1). The anticipated increase in hybrid vehicle sales especially in the US fleet will somewhat offset this trend.

Innovative recycling technologies such as Vinyloop® for PVC and Mobius for PU will improve recycling rates as well as the quality of recyclate.

For automotive interiors, there may be increased use of recyclate interior applications such as seats, acoustic barriers, and non-carpet flooring. It is unlikely that the recyclate concentration will rise above 5-10% within the next 5 years since auto OEMs are unwilling to add cost to gain recyclate content.

CAFE and lightweighting -- The U.S. corporate average fuel economy (CAFE) regulations require that the fleet of each OEM average 20.5 MPG and light trucks (SUVs, PUTs, and minivans) average 27.5 MPG. The light truck requirement will rise to 22.2 MPG by 2007. As shown in Exhibit 2, the establishment of CAFE and the value of weight savings involve profitability, and political considerations as well as technology considerations. The high share of Japanese transplant sales in the fuel-efficient small car sector will allow these OEMs to produce more of the less fuel-efficient light trucks.

Cost/profitability pressures-The current intense cost pressures on OEMs impact the entire interior supply chain. OEMs are approaching cost reduction by a variety of approaches. As illustrated in Exhibit 3, some of these are traditional automotive approaches, others result in pressures on the supply chain and will encourage:

- Structural changes in the supply chain
- Introduction of new process technologies capable of bringing modules to the assembly point at lower cost
- New materials combinations capable of cost reduction.

Process changes- Most interior modules are made from a series of separate steps. Process changes capable of reducing the number of manufacturing steps are gaining market share. Exhibits 4 and 5 compare typical current processes and a conceptual view of future, more efficient direct, combination processes. Some examples of this evolution toward simplified processes are:

- 2 and 3-shot molding for instrument panel (by Mitsubishi) and door pulls (by Schulman)

- In line compounding of long glass fiber reinforced PP instrument panel uppers (by JCI and Faurecia)

- In mold assembly of HVAC louvers.

Materials shifts- Most interior modules are made from a combination of skin/foam/substrate. The current materials used result in a difficult to recycle blend of materials, for example:

- PET textile/PU foam/ natural fiber filled PP substrate in door trim panels

- PVC skin/PU foam/ PP substrate in instrument panels

- PET textile/glass fiber reinforced PU foam/EPP countermeasures in headliners

- Nylon tufted face yarn/ PU foam/ EVA heavy layer in floor acoustic systems

Cost pressures will accelerate a shift to mono-materials constructions. Those mono-materials constructions that can be made in more cost efficient processes will gain market share. While not an acceptable solution for all constructions, polyolefins appear to be the most versatile candidates for skin/foam/substrate.

TPE role – Because of their versatility, TPEs are finding an increased role in automotive interiors and other applications and creating both increased recyclability and value-add opportunities. The families of TPEs and examples of value-add opportunities are illustrated in Exhibit 6. Their ability to meet automotive process and materials requirements are shown in Exhibit 7 and the interfaces with less recyclable thermoset elastomers are shown in Exhibit 8.

Coated Fabrics -- PVC coated fabrics are widely used for automotive seating in combination with leather. 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.

SUMMARY

European ELV legislation is a driving force for material substitution, especially in European vehicles. The convergent trend in European and US interior fabrication technologies will accelerate penetration of European technologies into the US fleet.

Cost pressures are a more immediate driving force and will accelerate a shift to mono materials constructions. Those mono-materials constructions that can be made in more cost efficient processes will gain market share. Fortunately, the new generation of mono-materials constructions substantially enhance recyclability. They will also accelerate the penetration of polyolefins and TPEs into skin, foam and substrate, textiles and body seals.

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.

b/mydox/papers/gpec doc

REFERENCES

1. Multiclient Study, "Automotive Interior Soft Trim...Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers," Robert Eller Associates, Inc. (August 2003)

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)

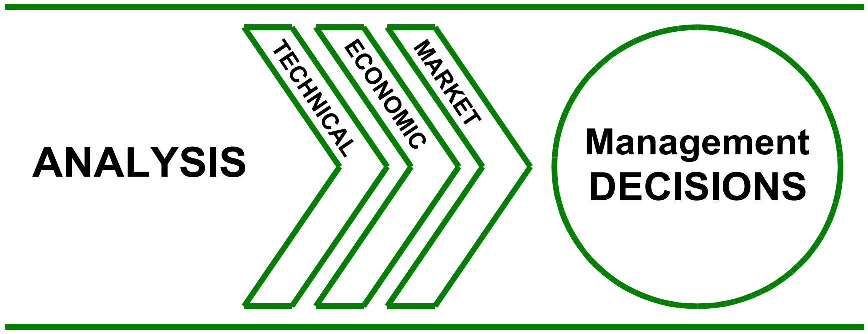
3. TPE TOPCON (December 2002), R. Eller presentation

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

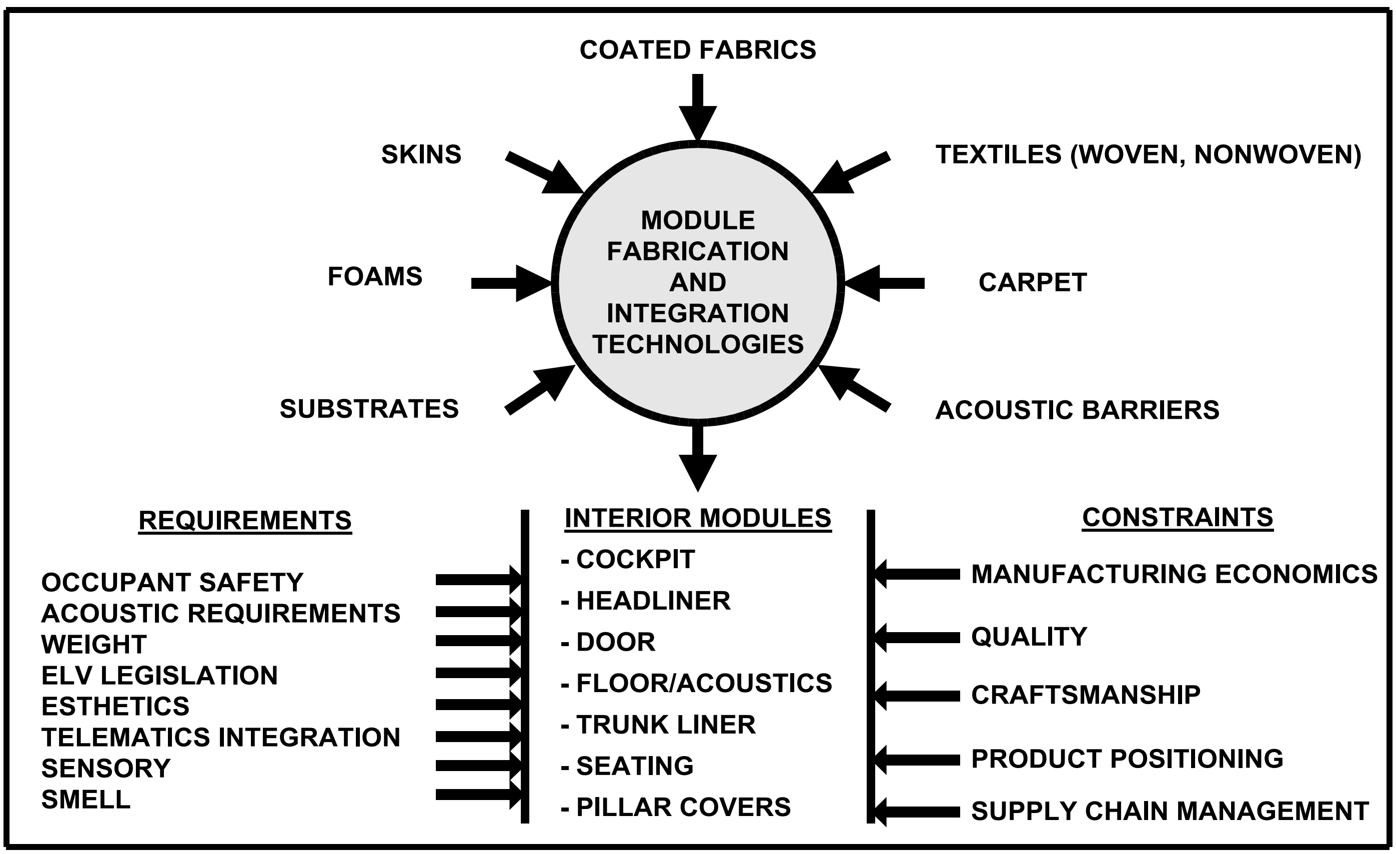
6. "Matériaux d'habitacle Automobile et Approche Sensorielle," Comfort Automobile et Ferroviaire; Le Mans, France; November 15, 2000; D. Nesa; S. Couderic; S. Crochmore.

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



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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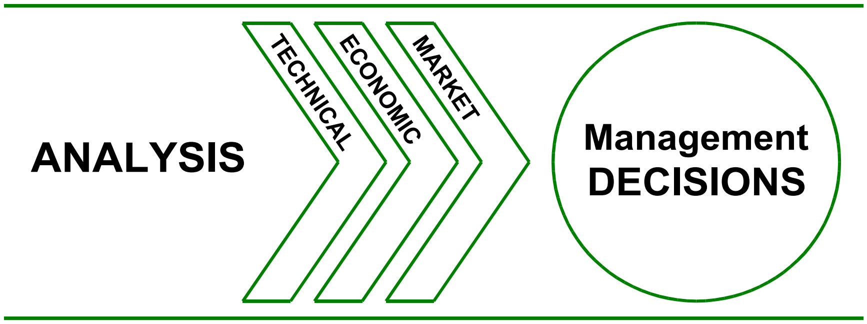
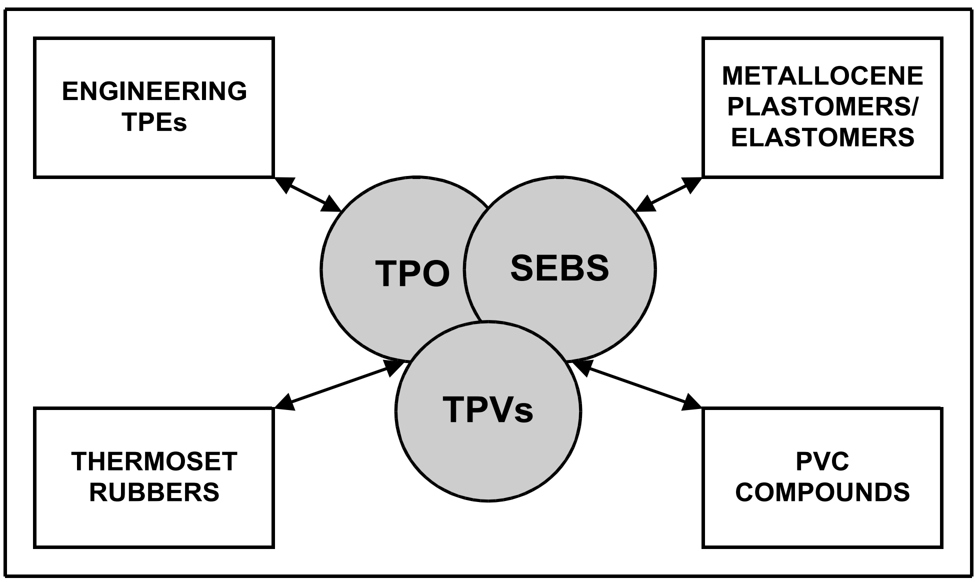


SEBS, TPV, and TPO-type Thermoplastic Elastomers ... Markets, Economics, Technology, Intermaterials Competition, and the Role of Metallocene Resins



Prospectus for a Euro/US/Japan Multiclient Industry Analysis

January 2000

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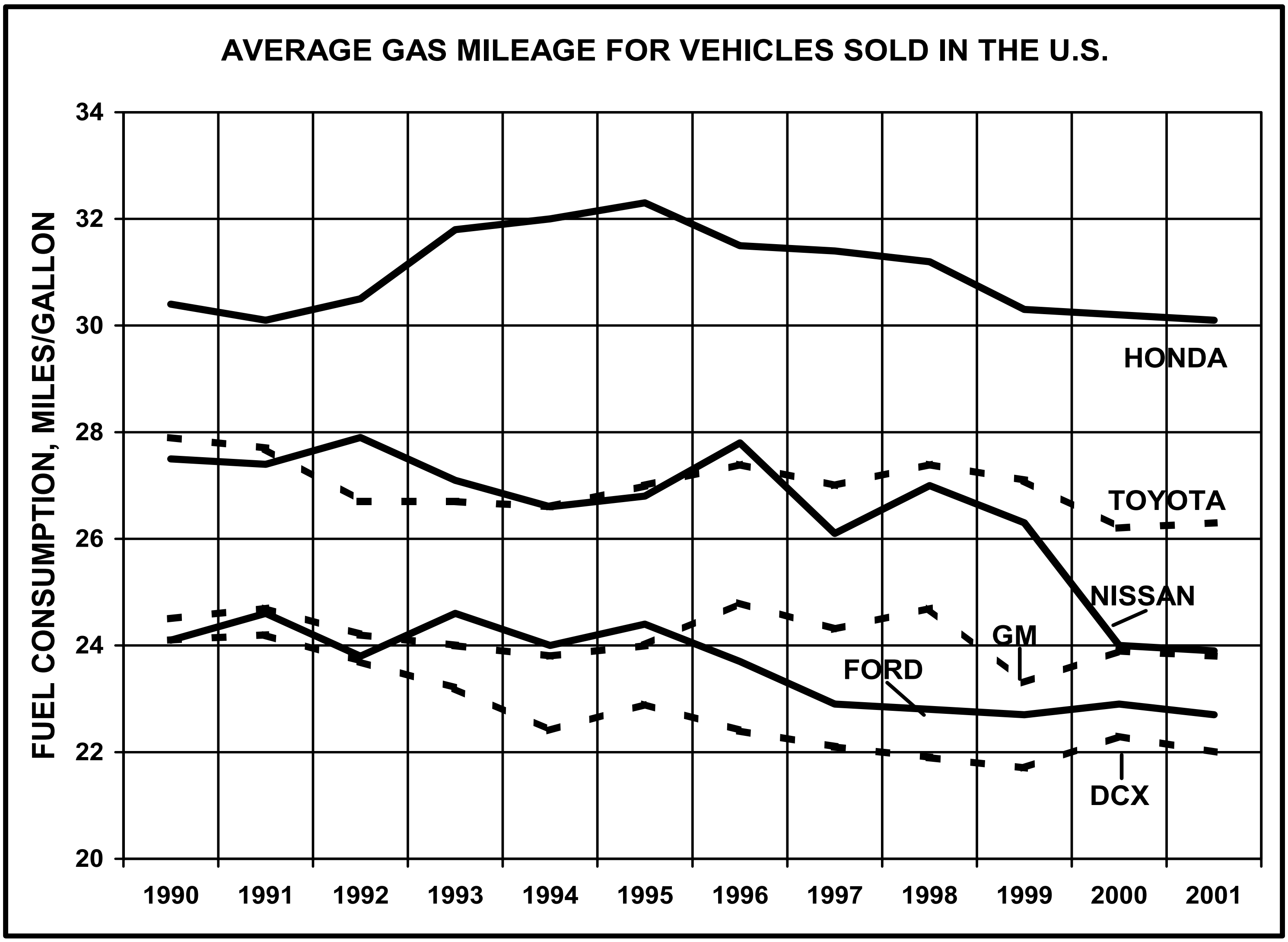
EXHIBIT 1

AVERAGE GAS MILEAGE FOR VEHICLES SOLD IN THE U.S.

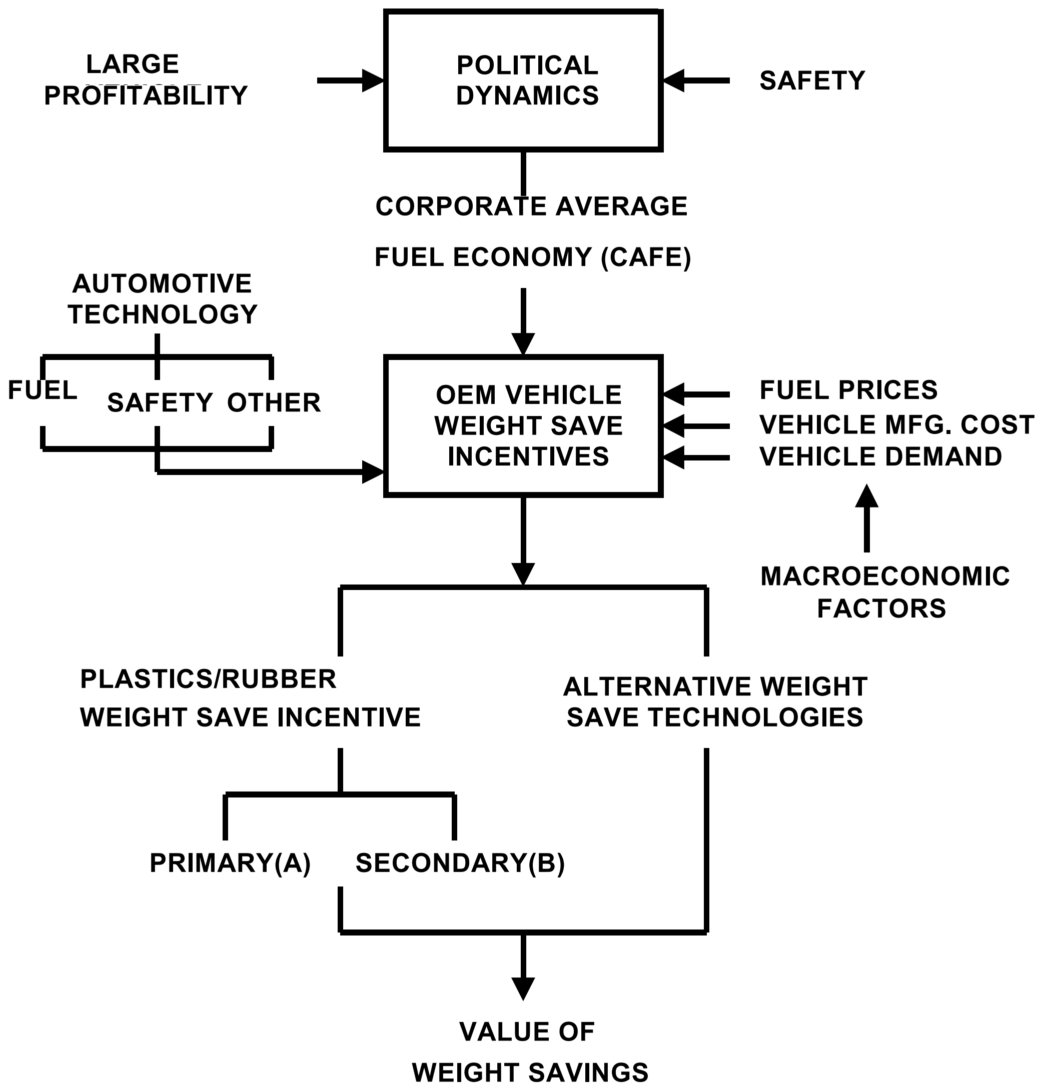
YEAR	AVERAGE FUEL CONSUMPTION PER VEHICLE (MILES/GALLON)					
	DCX	FORD	GM	NISSAN	TOYOTA	HONDA
1990	24.1	24.1	24.5	27.5	27.9	30.4
1991	24.2	24.6	24.7	27.4	27.7	30.1
1992	23.7	23.8	24.2	27.9	26.7	30.5
1993	23.2	24.6	24.0	27.1	26.7	31.8
1994	22.4	24.0	23.8	26.6	26.6	32.0
1995	22.9	24.4	24.0	26.8	27.0	32.3
1996	22.4	23.7	24.8	27.8	27.4	31.5
1997	22.1	22.9	24.3	26.1	27.0	31.4
1998	21.9	22.8	24.7	27.0	27.4	31.2
1999	21.7	22.7	23.3	26.3	27.1	30.3
2000	22.3	22.9	23.9	24.0	26.2	30.2
2001	22.0	22.7	23.8	23.9	26.3	30.1



SOURCE: UNION OF CONCERNED SCIENTISTS

EXHIBIT 2

FACTORS AFFECTING VALUE OF AUTOMOTIVE WEIGHT SAVINGS

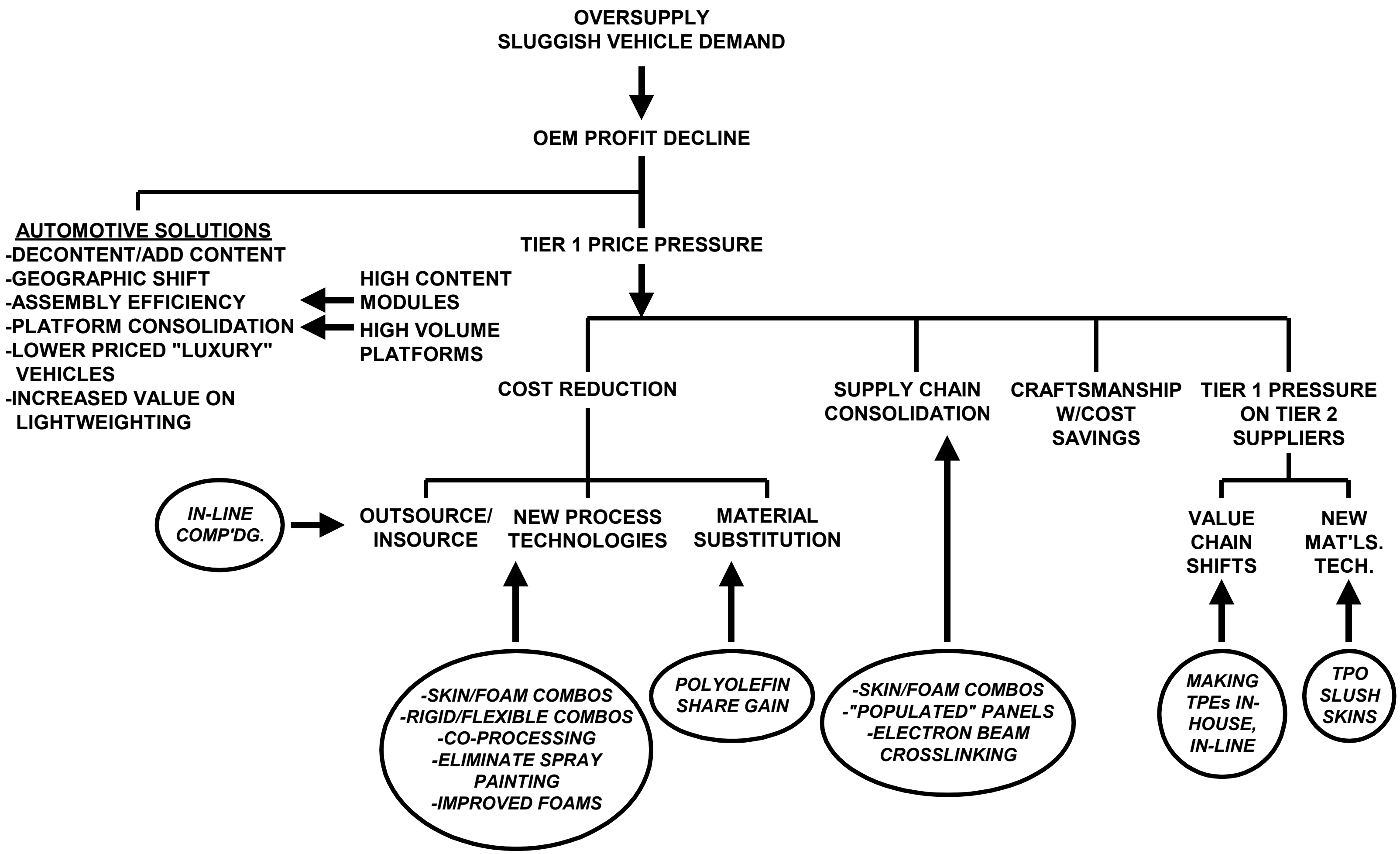


NOTES:
(A) E.G., VIA MATERIAL
(B) E.G., FROM PARTS

SOURCE: ROBERT ELLER ASSOCIATES, INC.,
b/mydox/topcon 03/auto wt save

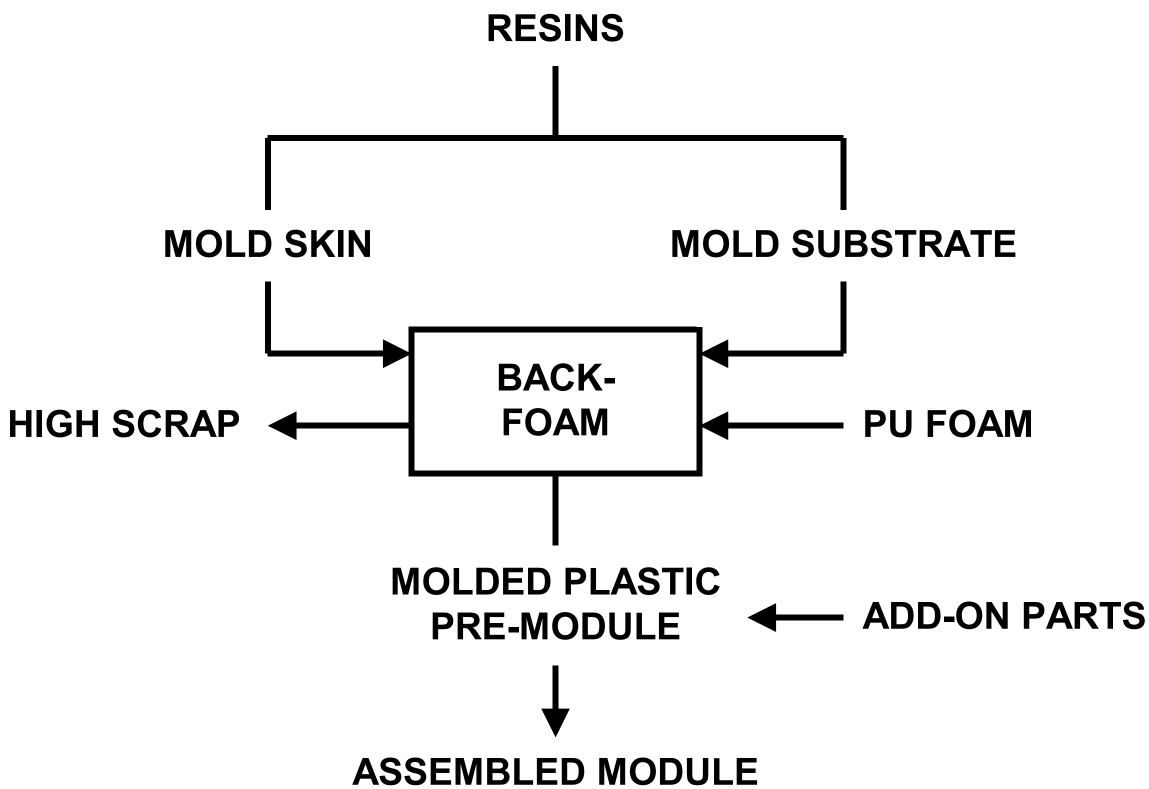
EXHIBIT 3

AUTOMOTIVE OEM/SUPPLIER DYNAMICS AND EFFECT ON O-TPEs



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003
re/mydox/bkg-autooemdyn 03.vsd

EXHIBIT 4
CURRENT MODULE FABRICATION (INEFFICIENT)

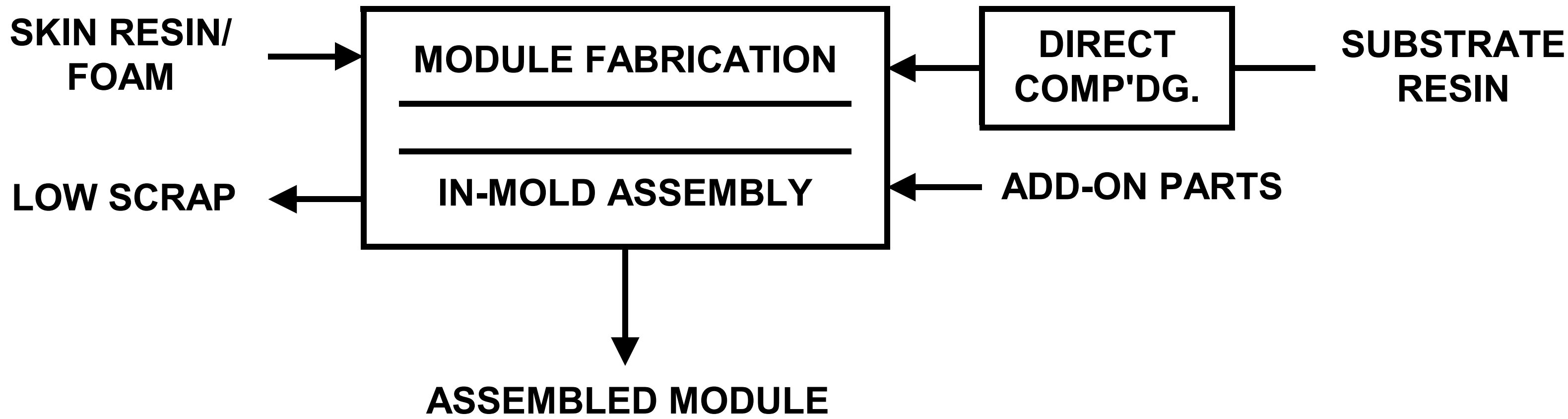


4-STEP OPERATION

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

aes/bkg-mod fab 03.vsd

EXHIBIT 5
FUTURE MODULE FABRICATION (IDEAL)



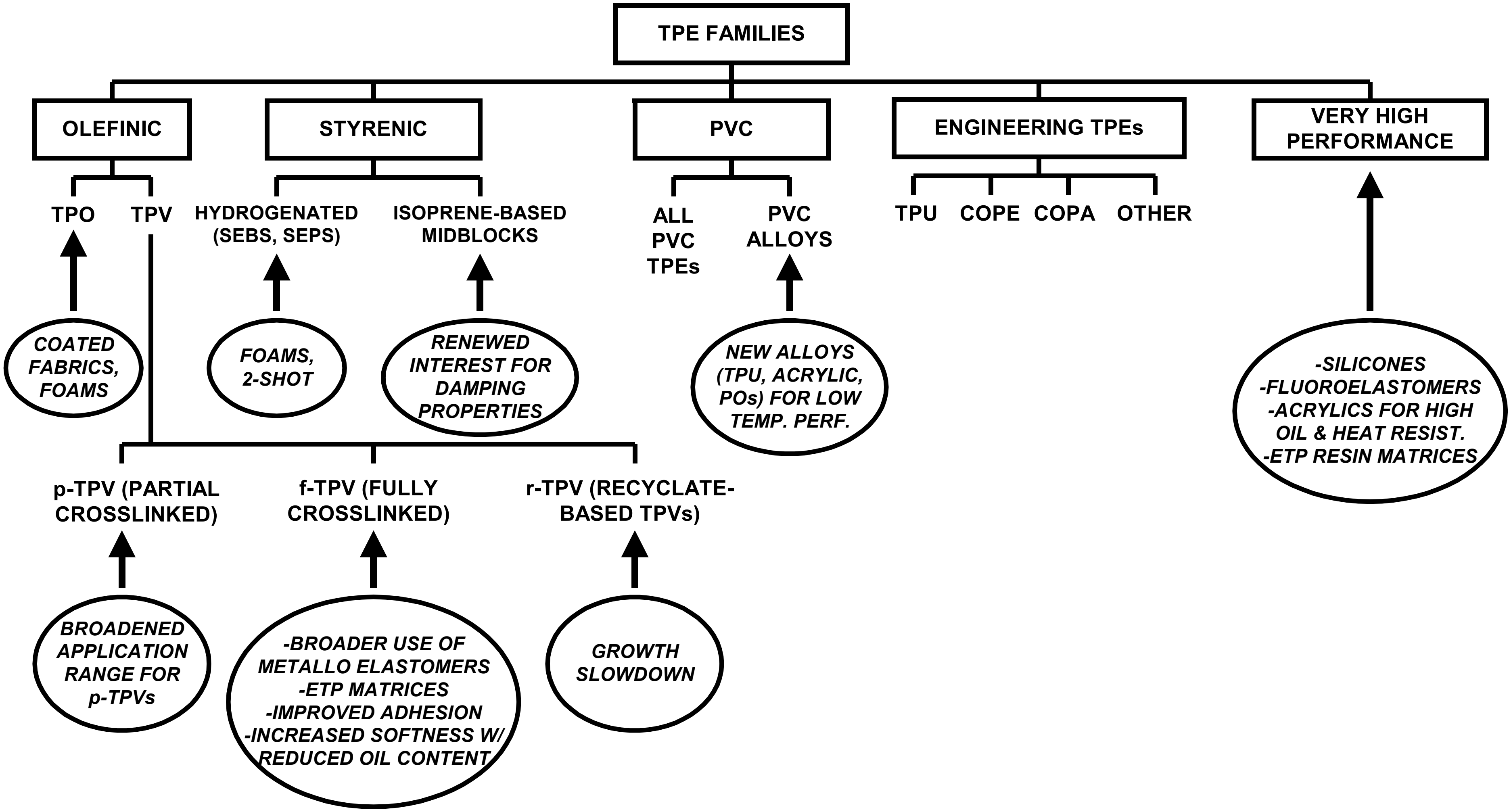
(IDEAL) 1-STEP OPERATION

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

bkg-one step 03.vsd

EXHIBIT 6

GROWTH AND VALUE OPPORTUNITIES IN THE TPE FAMILIES



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003
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EXHIBIT 7

TPEs' ABILITY TO MEET AUTOMOTIVE MATERIAL/PROCESS REQUIREMENTS

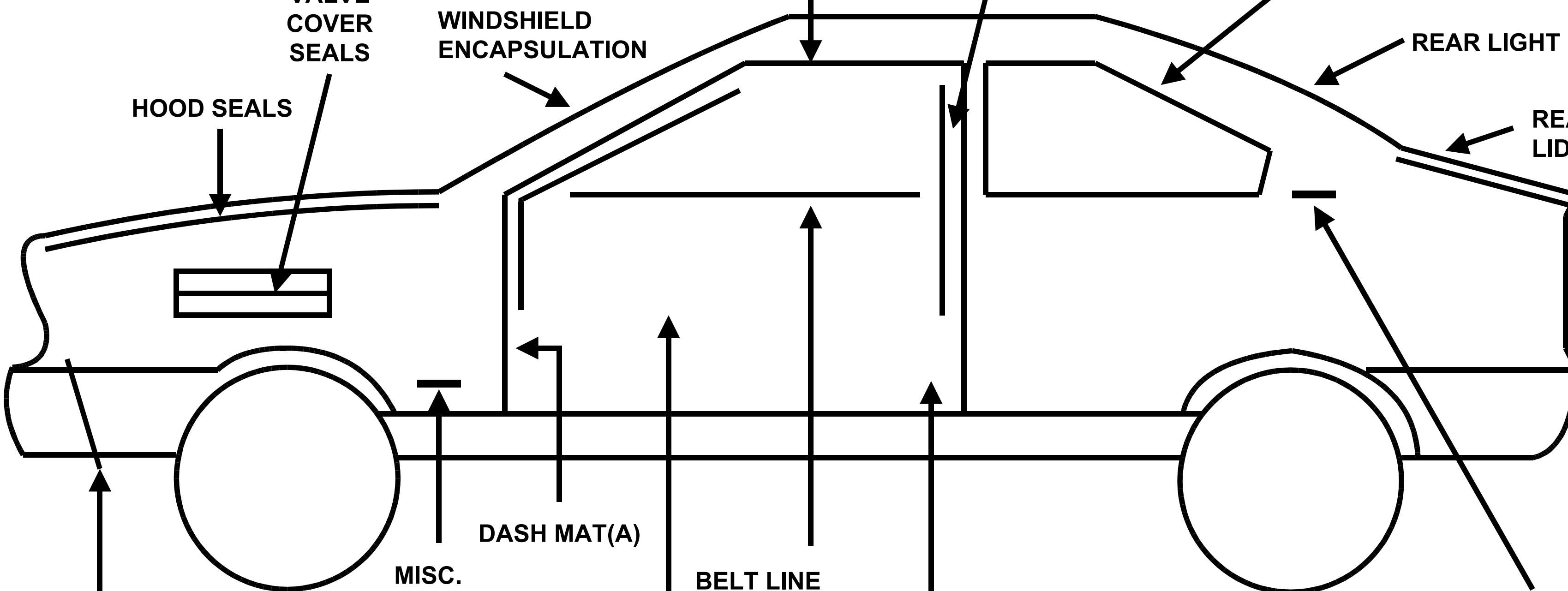
SYSTEMS COST SAVINGS	TPE IMPLICATIONS/EXAMPLES
SYSTEMS COST SAVINGS	-RIGID/FLEXIBLE COMBINATIONS -TPE BODY SEALS -TWO-SHOT MOLDING OF LARGE PARTS
WEIGHT SAVINGS	-INCREASED TPE FOAM USE -SUBSTITUTE FOAMS FOR HEAVY LAYER
SOFT TOUCH	-TWO-SHOT MOLDING (ESPECIALLY LARGE PARTS) -COEXTRUSION OF SOFT TOUCH SURFACED 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

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

topcon 03

EXHIBIT 8

TPE/RUBBER COMPETITIVE INTERFACE IN AUTO APPLICATIONS



NOTE: (A) ACOUSTIC/FOAM OPPORTUNITY

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2003

tperintface 03.vsd

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	X				
BELTING		X			X	X		
BODY SEALS		X	X					
BOOTS/BELLOWS		X				X		
COATED FABRIC	X			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			X				
UNDERHOOD DEFLECTORS							X	X
IN-MOLD DECORATION								X

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