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NEW FRONTIERS FOR PLASTICS IN AUTOMOTIVE INTERIORS

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OUTLINE

- *"Innovate or die"– Peter Drucker*
- *"Innovation is the difference between the same perspective and an entirely new one…Invesco*

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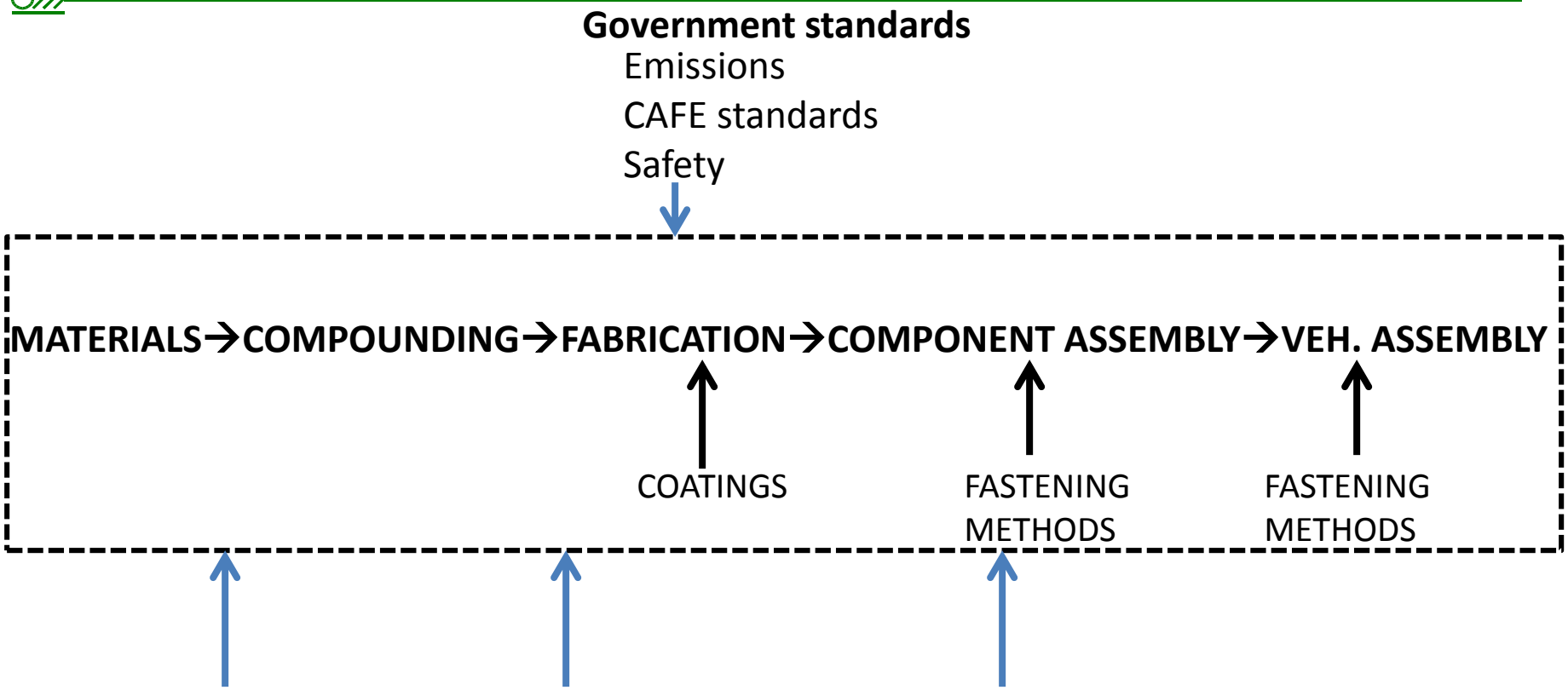
- **Interiors supply chain implications**
- **Innovation targets**
- **Paths to innovation**
- **Enablers/driving forces for interiors innovation**
- **Foams**
- **Acoustics**
- **Seating**
- **Soft touch**
- **Body/glazing seals**
- **Unique new materials**
- **Fiber reinforced plastics**
- **Luxury effect examples**

THE INTERIOR PLASTICS SUPPLY CHAIN AND ITS INFLUENCES



SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

AUTO INTERIORS SUPPLY CHAIN IS CONSOLIDATING

INTERIOR TIER 1	2014 INTERIOR REVENUES, $Bn	ACQUIROR	NOTE/STATUS AS OF 041615
Magna	3.0(a)	Grupo Antolin	- Pending agreement to sell $2.4BN out of estimated $3.0 BN interiors business. - Excludes seating
JCI Interiors	3.5	Yanfeng Auto	- Completed (5/14) via non-cash transaction - Excludes seating
Visteon Interiors	1.0	Cerberus Capital	- Completed→ Reydel(Cerberus) - Visteon sold 50% share in seating JV to partner Yanfeng Visteon Automotive Trim Systems in 2013
Faurecia	5.0	None yet	PSA owns 57% of Faurecia

Note:
- Emerge from overcapacity/low profitability
- Increased purchase and pricing power

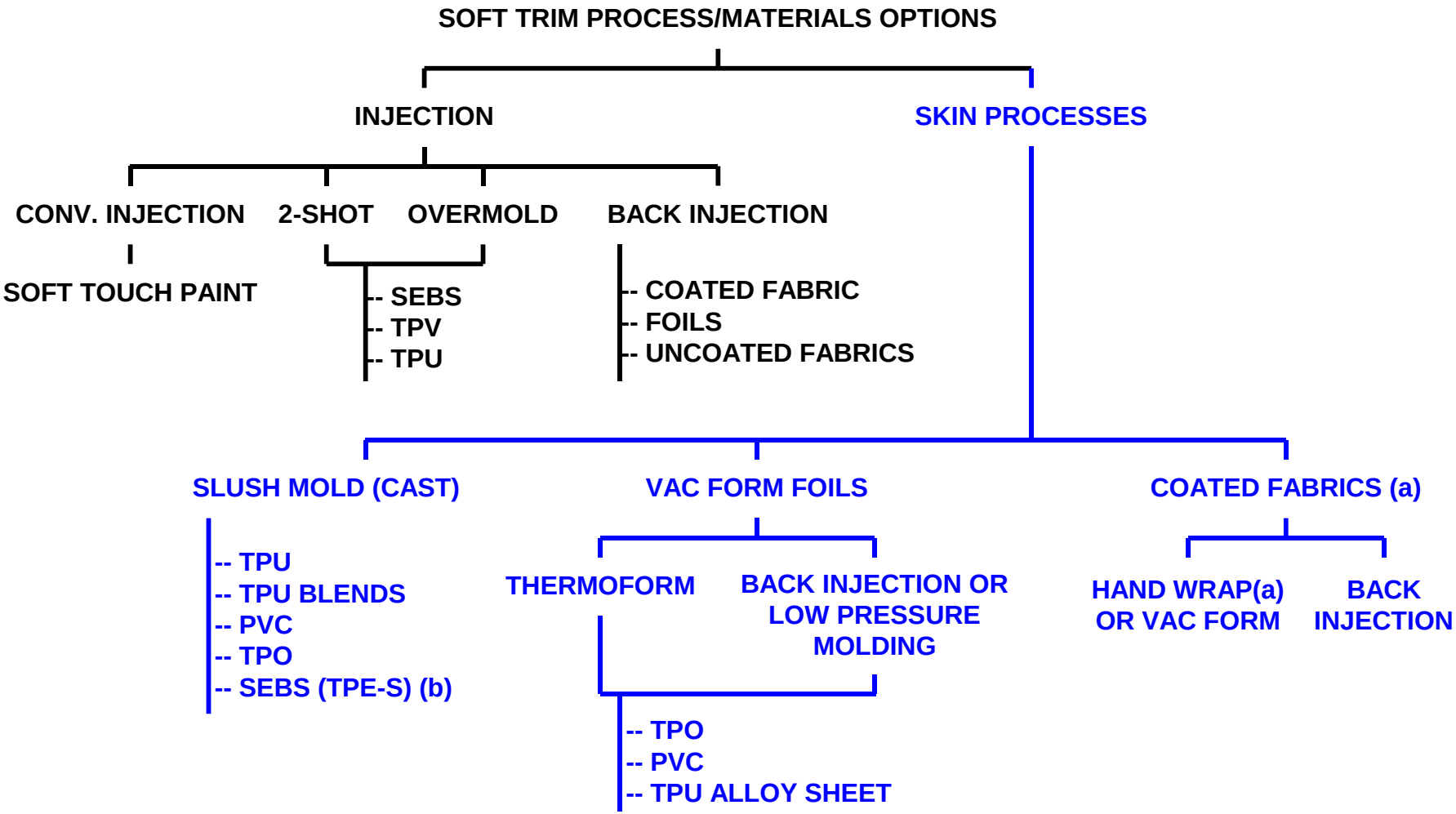
SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

FRONTIERS FOR INTERIORS INNOVATION

TARGET	COMPONENT	PRIMARY OBJECTIVES	NOTE/CANDIDATES
Seating	PU foam	Bio-components in foam chemistry	Started
	Frame	- Thinner seat cross-section - Long glass/carbon fiber reinforced ETPs.	Heavy weight ←Target
PP comp'ds	Panels/ IP substrate	- Thinner, low gloss, + grain - Increased structural, bio	Improved: fillers, flow
-IP - Door trim - Console	Skins	Competition: - Slush (PVC, TPU), - TPO sheet- o-TPV (recently) - Single/2 shot injection	- Process cost reduction - Avoid "cheap plastics" look - Soft touch
Acoustics	Floor, door, firewall, headliner	- Get decibel level down without weight gain - Reduce BSR - Recent major target	- Foam, fiber, heavy layer combinations - PE/rigid constructions
Ductwork	- Headliner, IP	Reduce: BSR, weight	Polyolefin foams

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

SOFT TRIM: TARGET FOR INTERIORS INNOVATION



NOTE: (a) Polyurethane dispersion (PUD) coated fabrics gaining share
(b) Recently introduced

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

MODIFIED APPEARANCE OF “A” SURFACES

Pearlescent film
Application: 2015 Nissan Murano
Note: Pearlescent films are used in labels, decorative ribbon
Photo source: Wards Automotive

SOME PATHS TO INTERIOR PLASTICS INNOVATION

- **Extension of materials properties + efficient fabrication technology:**
  - Improved rheology o-TPVs + single shot injection

- **Extension/combination of capabilities:**
  - Borealis' 20% long glass fiber grades utilizing integral foaming
  -Combining vibration damping TPEs with rigid plastic substrate→ reduced BSR

- **Eliminating limitations:**
  - Reformulating slush PVC to eliminate fragmentation during airbag deployment
  - Colored long glass reinforced composites

- **Finding new paths:** Multiple sustainable, green solutions

- **Substitutions that solve problems: (Weight save, BSR)**
  - Substituting polyolefin foam for rigid ducting

EXAMPLE ENABLERS/DRIVERS FOR AUTO INTERIOR PLASTICS INNOVATION

ENABLERS

- **Catalyst innovations**
  - Metallocene EPDM
  - POEs

- **Compounding:** Broadening the performance envelope

- **Plastic process technology improvement examples**
  - Foaming improvements
  - Co-processing (co-blow, co-extrusion, co-injection)

- **3-D printing:** Speeding prototype production and evaluation

DRIVERS

- **Drive for "green" solutions:** Driving bio-plastics and natural fiber substitution

- **MPG regulations:** Driving metal substitution, weight reduction

EXAMPLE DRIVING FORCES IN AUTOMOTIVE → INNOVATIONS

- **Increased joining via bonding → adhesives growth and functionalization of polyolefins**

- **Improving acoustics (acoustic barriers, seals for wind noise, buzz/squeak/rattle)**

- **EMF shielding via conductive fillers, back injection, films**

- **Weight save via:**
  - **thinwalling**
  - **metal substitution**
  - **lighter weight plastics**
  - **glass substitution (e.g. with polycarbonate)**
  - **filler substitution (e.g. with natural fibers or lighter fillers)**

- **Improved esthetics (eliminate "cheap plastics look")**

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

TWO EXAMPLES OF PLASTICS PROCESSING INNOVATIONS

- **DYNAMIC VULCANIZATION**

- **FOAMING**

- **Both have had staying power:**
  - **Technology platforms for product and process development**
  - **Broad application range**
  - **Continuing evolution of applications**
  - **Basis for evolution of process variations**

DYNAMIC VULCANIZATION

- **Crosslinking elastomer ”islands” in a plastic resin “sea” or matrix during extrusion**

- **Fundamental breakthrough was crosslinking of fine dispersion during extrusion**

- **Example of innovation driven by intensive investment and creative marketing to “shape” new markets**

- **The basis for:**
  - **olefinic TPVs (o-TPVs e.g. Santoprene from ExxonMobil) based on EPDM in PP**
  - **other island/sea, elastomer/plastic compositions**

- **Broad range of interiors applications:**
  - **skins, seals, hoses, body/glazing seals), boots/bellows**

SOURCE: ROBERT ELLER ASSOCIATES LLC,2015

WHAT IS HAPPENING IN LONG FIBER REINFORCEMENT

- **LGF PP:**
  - reaching material property limits
  - innovation now design dependent

- **Interior targets: door hardware modules, IP substrates, seat frames**

- **Growth of LGF - polyamides**

- **Flow enhancers → improved surface finish (Velocity® high flow grades from Plasticomp)**

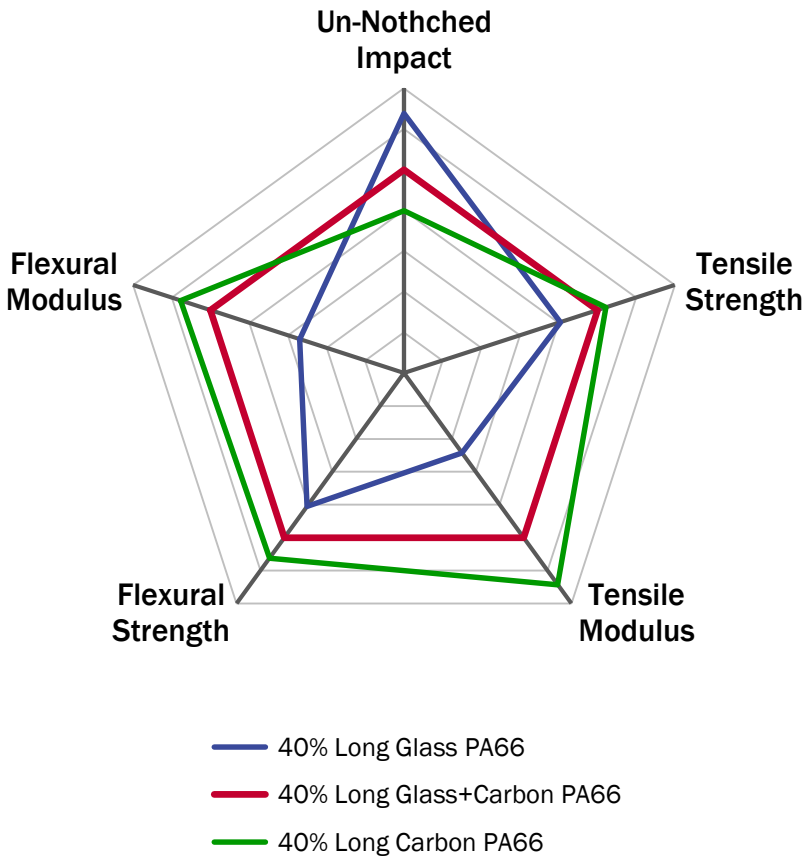
- **Induction heating: (e.g. from RocTool) → improved surface finish**

- **Entry of long carbon fiber (LCF): performance and weight save advantage over LGF**

- **LGF/LCF hybrids: performance/cost stepping-stone**

GLASS FIBER-CARBON FIBER HYBRID

- **BALANCED PERFORMANCE**
  - Glass fiber toughness
  - Carbon fiber strength
- **PA66 20%GF 20%CF**
  - Impact
    - 78% of glass fiber
    - 125% of carbon fiber
  - Strength
    - 124% of glass fiber
    - 96% of carbon fiber
  - Stiffness
    - 186% of glass fiber
    - 87% of carbon fiber



SOURCE: PLASTICOMP 2015

TECH. PLATFORM: PP/FIBER REINFORCED DOOR HARDWARE MODULE

CANDIDATE MATERIALS: PP REINFORCED WITH LONG GLASS FIBERS OR 40% CELLULOSE FIBERS

SOURCE: BROSE

CURRENT/PPOTENTIAL POLYOLEFIN FOAMS INTERIOR APPLICATIONS

HEADLINER

DUCTS IN HEADLINER

INSTRUMENT PANEL SKINS

TRUNK COMPONENTS(a)

DOOR TRIM PANEL & MEDALLION

DOOR WATERSHIELD

FLOOR DUCTS

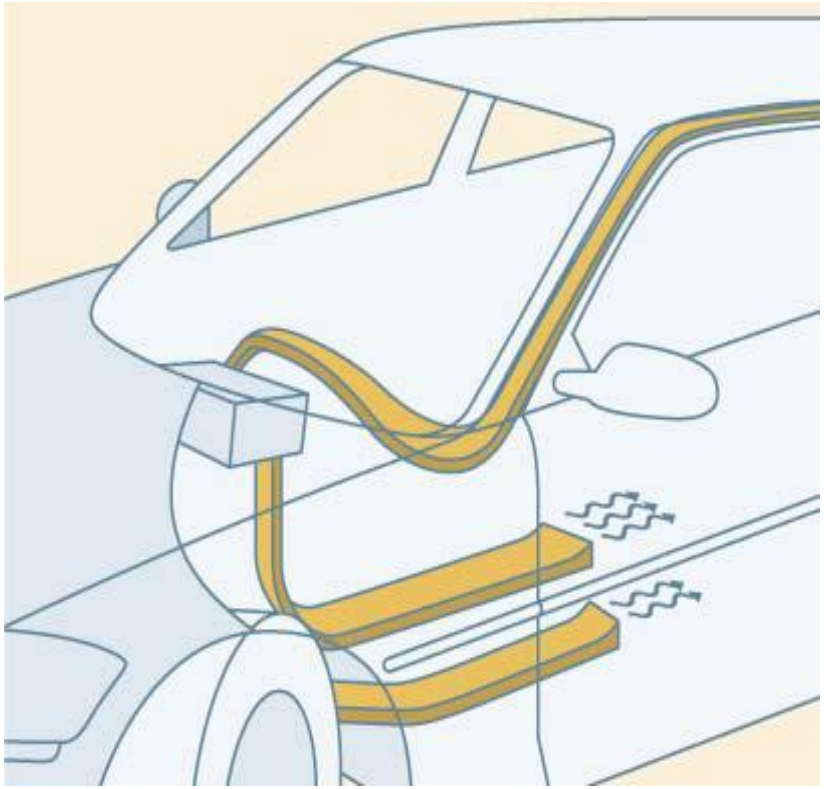
ACOUSTICS(a)

INTERIOR PANELS WITH DECORATIVE SURFACES(a)

Note:
(a) EPP bead foams

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

AIR DUCTS: TARGET FOR POLYOLEFIN FOAMS



OVER 10 AIR DUCTS PER CAR

EXAMPLE AIR DUCT
MATERIAL: PP FOAM
PROCESS: TWIN SHEET FORMING
SUPPLIER: SEKISUI ALVEO

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

INTERIOR TARGETS AND COMPETITORS

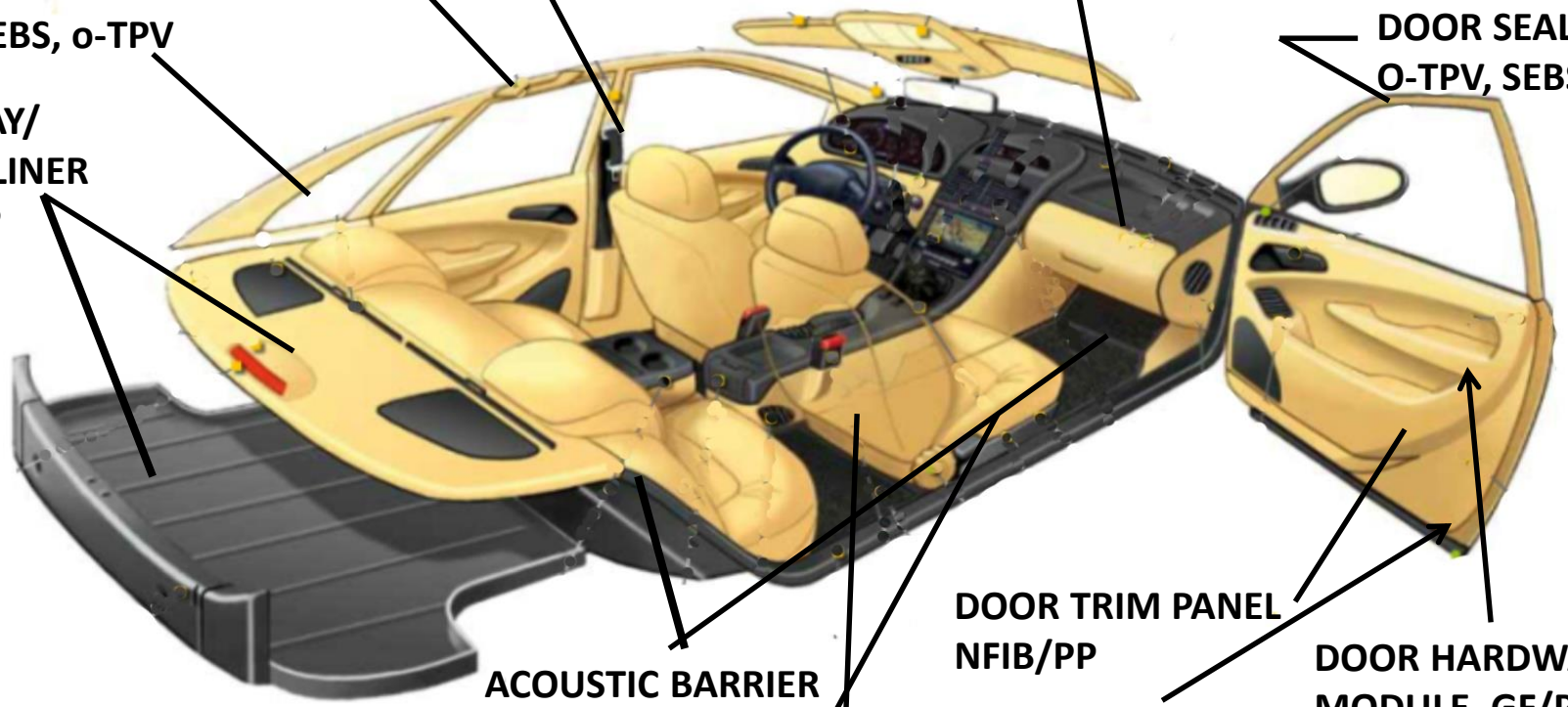
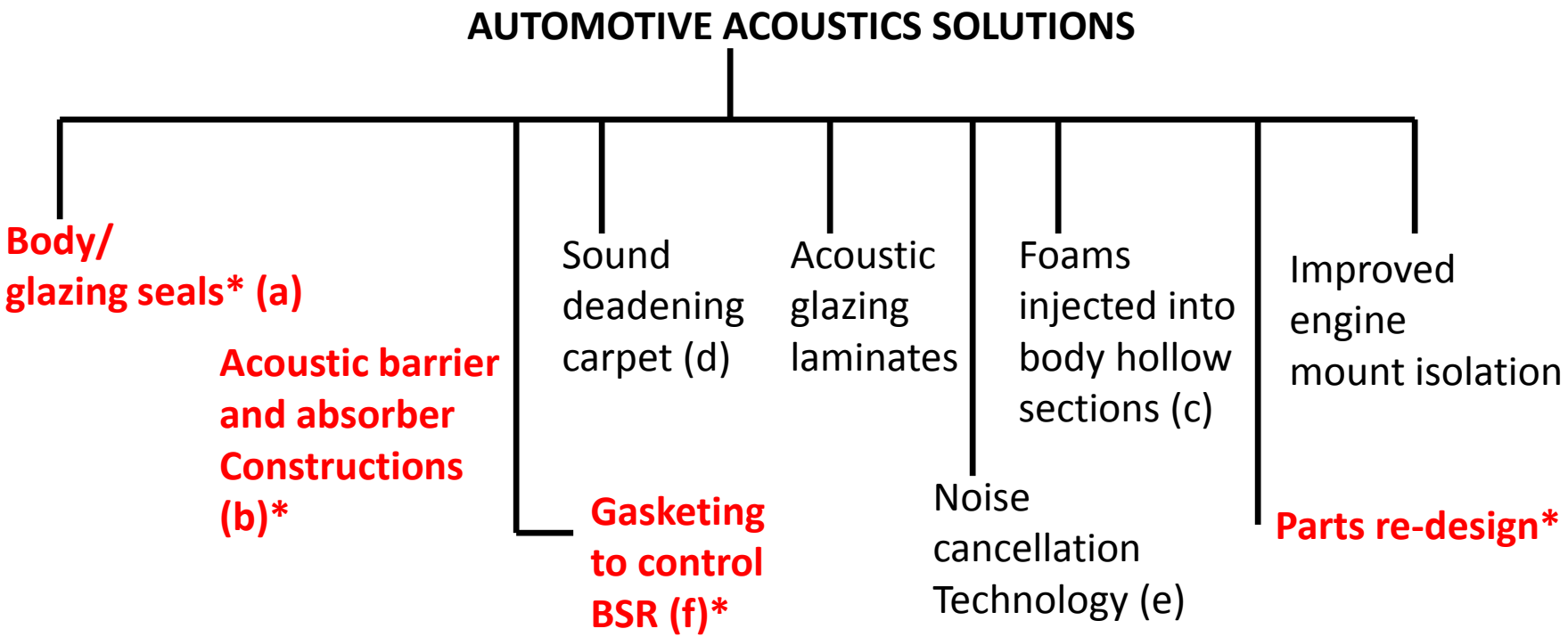


PHOTO SOURCE: So.F.teR GROUP

TARGETS: ROBERT ELLER ASSOCIATES LLC., 2015

AUTO ACOUSTICS CONTROL TECHNOLOGIES : ROLE FOR TPEs



Note: *= current or potential TPE opportunities

(a) High growth application for SBC and o-TPVs

(b) Lightweight dash mats and heavy duty barriers (e.g. from Cascade Engineering). includes polyolefin foams

(c) For example Betafoam™ from Dow based on PU foams

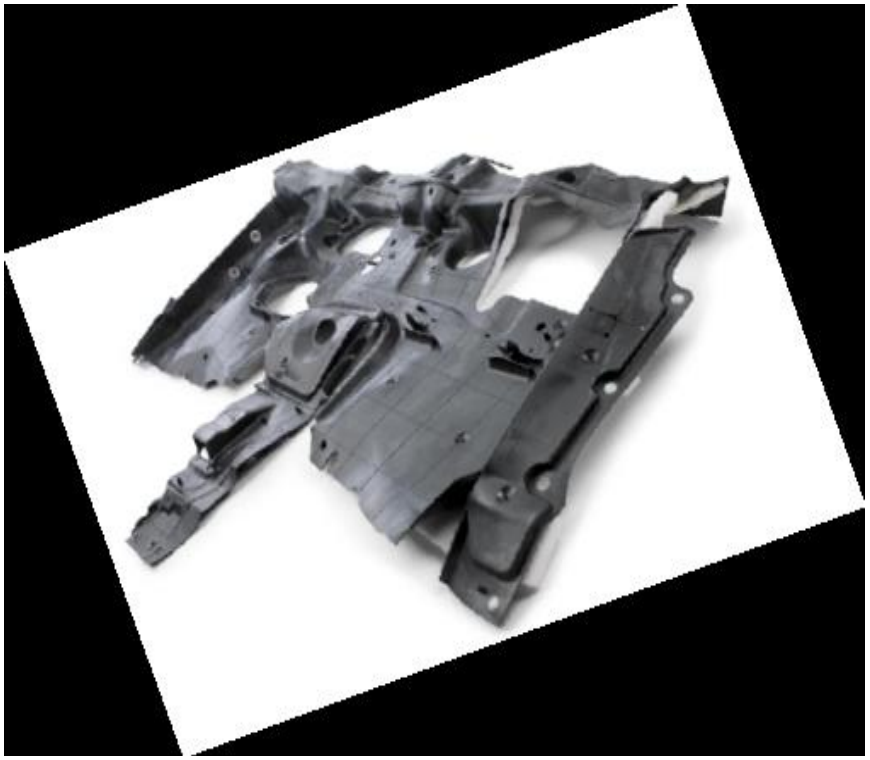
(d) For example from IAC/Stankiewicz

(e) Becoming common via feedback microphones (e.g. Honda Accord and Chevrolet Impala)

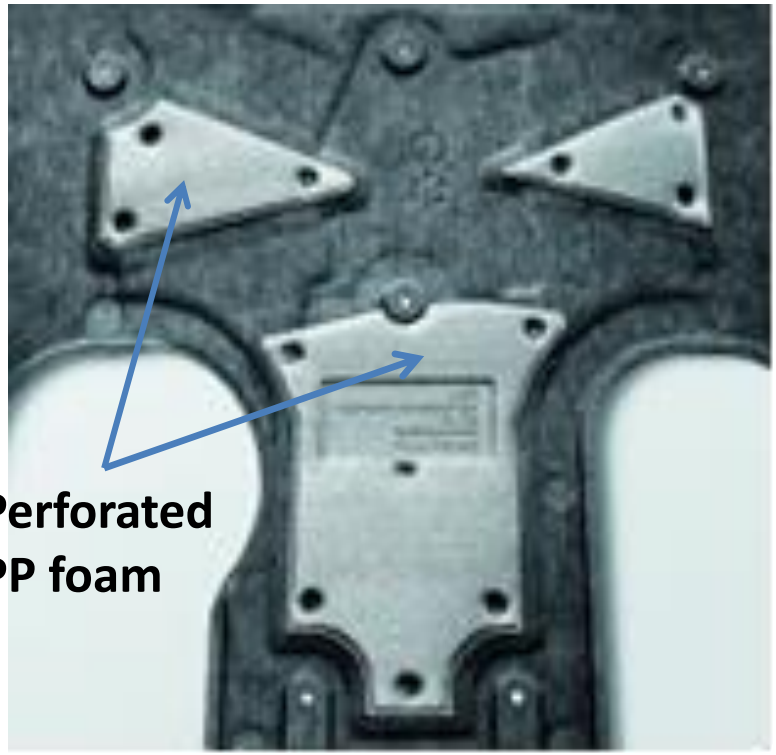
(f) BSR= Buzz, squeak, rattle: opens opportunity for vibration damping TPE layer on plastic substrates

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

ACOUSTIC TARGETS FOR POLYOLEFINS/TPEs/FOAMS



DASH MAT
SUPPLIER: CASCADE ENGINEERING

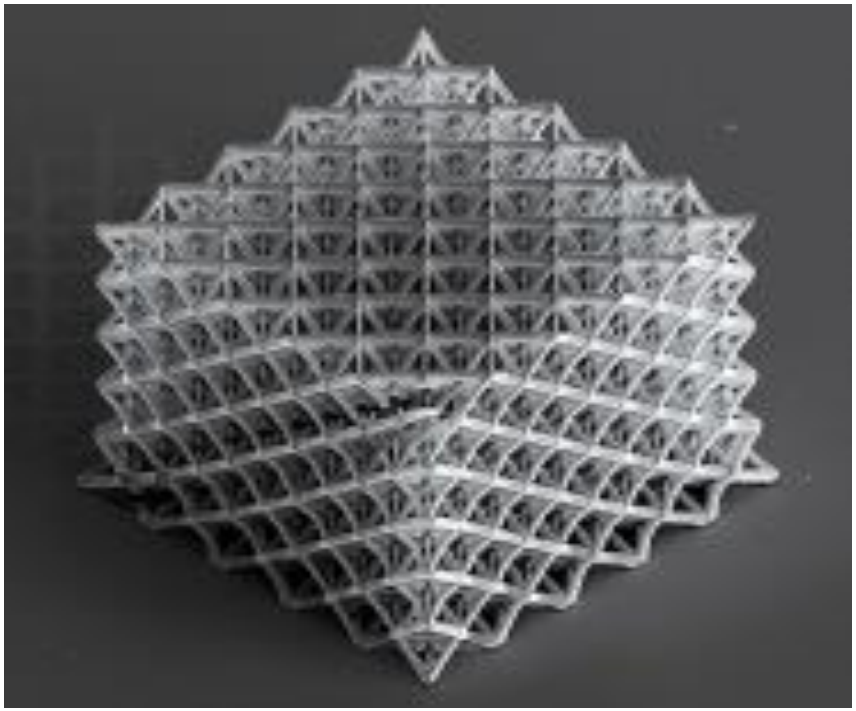


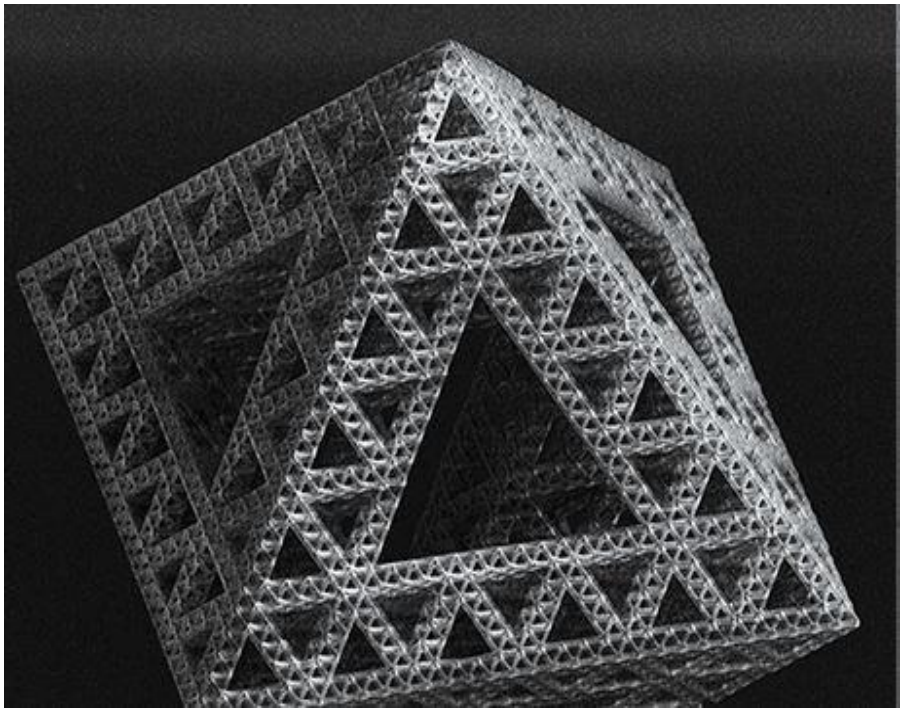
FLAT ABSORBER FOR GEAR DRIVE
NOTE: WHITE AREAS ARE MICRO-PERFORATED POLYOLEFIN FOAMS

FOAM SUPPLIER: SEKISUI ALVEO

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2015

FILLER STRUCTURES: TAILORED AT NANOSCALE





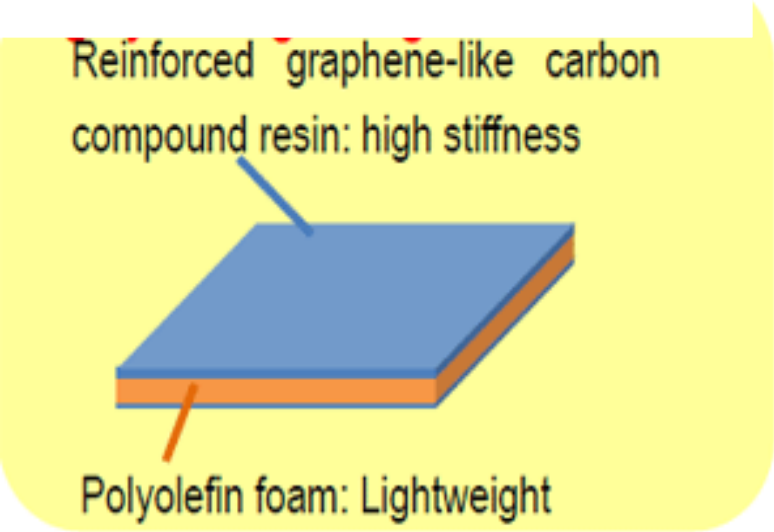
Ceramic cube:
50 micrometers per side, ultralight - mostly air
Strong, not brittle
Precise control of structure at nanoscale

- **increased energy density of batteries with weight save**
- **space at nanoscale to precisely control flow of heat and light**
- **others?**

SOURCE: MIT Technology Review , vol. 118 no. 2, Caltech

INNOVATION EXAMPLE: COMBINING MATERIALS TECHNOLOGIES→ SYNERGY

HIGH STIFFNESS/LIGHTWEIGHT SHEET



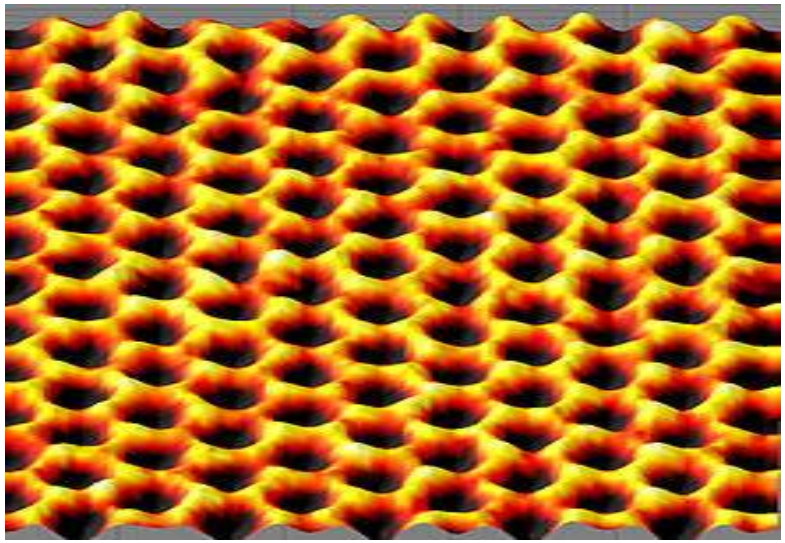
Combination yields:

- high stiffness from graphene-like layers
- lightweight /thickness effect of PO foam
- easily molded

Target auto applications:

- sandwich structures
- battery
- electronics
- composites

GRAPHENE



Scanning probe microscopic image of graphene, an allotropic form of carbon in a 2 dimensional, atomic scale hexagonal lattice.

One atom at each vertex→ C-C bonding

- 100x stronger than steel
- efficient heat, electrical conductor
- nearly transparent

PHOTO SOURCE: SEKISUI CHEMICAL CO., LTD

SUMMARY

- Globalized interiors supply chain is consolidating

- Interiors is a major innovation zone with many intermaterials/interprocess challengers to incumbents

- The major drivers/opportunity frontiers are:
  - acoustic improvement
  - weight save
  - luxury look and feel (haptics)
  - process improvement to replace outdated fabrication technology
  - active safety
  - electrical/electronic architecture

- The major challengers are
  - foams (several types)
  - fiber reinforced composites
  - thermoplastic elastomers(TPEs)
  - new generation fillers/reinforcements
  - improved conductive materials