• Identify innovative trends in interior materials and processes

• Examine their significance

• Provide examples for:
  - acoustics
  - foams
  - skins
  - coated fabrics
  - composites/3D printing
  - the human machine interface (HMI)

• Some innovative interiors technologies have been omitted, for example:
  - composite floor/combined with damping foams
  - hybrid cross car beam
  - acoustic headliner
  - drive-by-wire which could → weight/cost save via elimination of:
    -- steering shaft
    -- brake pedals
The HMI evolution:
- Buttons → touch screens → smart materials and thin film technologies
- Wi-Fi interiors as enabling technology for voice activation

Convenience and Comfort:
- Trim materials: soft touch, luxury feel, even lower gloss
- Continued VOC reduction
- Improved ergonomics

Stronger, Lighter, and Integration:
- More stronger/lighter materials: weight reduction
- Parts integration, “smart” materials where feasible

Environmental, Recycling:
- Today: Lower oil/gas price challenge recycle efforts /fuel economy
- Continued drive for sustainability
- Government directives as driver

Acoustics: Cabin quietness, essential element for perception of refinement

SOURCE: INTEVA; ROBERT ELLER ASSOCIATES LLC, 2016
INTERIOR DESIGN ELEMENTS: ROLE OF TECHNOLOGY INNOVATIONS

CONSUMER NEEDS AND WANTS

TECHNICALLY FEASIBLE

MATERIALS AVAILABILITY

MEET SAFETY/CAFE STANDARDS

FABRICATION PROCESSES

HARMONY BETWEEN INTERIOR COMPONENTS

LAUNCH TIMING

COMMERCIAL VIABILITY

GOOD DESIGN

HAS PROFITABILITY BEEN DRIVEN OUT OF THE SUPPLY CHAIN?

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
NOTE:

Indicates recent share gain, “smart” coatings could enter several material types

(a) Polyurethane dispersion (PUD) coated fabrics gaining share, improved TPO grades and SEBS will challenge

(b) Growth process

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
INTERIOR PROCESSES/MATERIALS: FUTURE DIRECTIONS

MATERIALS:
- Natural fiber reinforcement
- Natural oil polyols (NOPs) from renewable resources → PU foam, COPE TPEs
- Cellulosic nano reinforcements
- Role for graphenes
- Role for carbon fibers
- Smart textiles and thin film sensors

PROCESSES:
- 3D printing
- Smart coatings
- Wi-Fi interiors

FUNCTIONS:
- LED lighting
- Sensing
- Voice activation
- Shielding

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
MAGNESIUM: INTERIORS GROWTH RESTARTING

- Density advantage vs steel and aluminum. Recent growth started in Europe
- Higher per kg cost: Mg (3.75); Al (1.54); steel (0.40-0.98)
- Ability to mold in thick/thin sections (partially offsets higher $/kg raw material cost)
- Average Mg usage/vehicle in NAFTA still small: ~ 10 lbs

SOURCE: ROBERT ELLER ASSOCIATES LLC 2016
CARBON: MANY FORMS ➔ INNOVATIVE APPLICATIONS
GRAPHENE APPLICATIONS IN AUTO INTERIORS

SMART TOUCH

Hands on sensing

Seat comfort
Auto adjust
Heating

SMART DISPLAYS

SOURCE: GRAPHENICS; UNIVERSITY OF ALABAMA OFFICE OF VICE PRESIDENT FOR RESEARCH AND DEVELOPMENT; ALABAMA INNOVATION AND MENTORING OF ENTREPRENEURS
GRAPHENE APPLICATIONS IN AUTO INTERIORS (CONT’D)

CONDUCTIVE FABRICS/THREAD

NEW COATINGS

SOURCE: GRAPHERNICS; UNIVERSITY OF ALABAMA OFFICE OF VICE PRESIDENT FOR RESEARCH AND DEVELOPMENT; ALABAMA INNOVATION AND MENTORING OF ENTREPRENEURS
3D PRINTING: POTENTIAL FOR EXPANDED ROLE IN AUTO INTERIORS

- Major enabling technology: beyond prototype manufacturing
- Benefits: In combination with carbon fiber (or other fiber/fabric reinforcements), parts with:
  - No/low waste
  - High temp/high strength/light weight/versatile shapes

- Potential interior targets: XC beam, floor and roof modules, mechatronics (e.g. in door)

- 3D = mfg. + use of composites + scale up = high-potential revolution

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
GROWTH MARKET FOR SBC-TYPE TPEs: FLOOR MATS

- Early-mid growth stage
- OEMs entering to capture market
- Ability to add styling cues
- Post consumer, post industrial recycle
- High value –add
- An aftermarket product
- Key enabler: laser sizing
- Based on SEBS/SBS formulations

- Typical hardness 50-75 Shore A
- Non slip, scratch /abrasion resist
- Can be used in multiple positions
- Easily colored
- High capital investment for molding equipment

PHOTO: THERMOFLEX CORP; HEXPOL TPE; COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2016
CONNECTED/AUTONOMOUS CAR: OPPORTUNITIES FOR PLASTICS AND TPEs?

Printed circuits
RF Shielding
Housings
High temp plastics and TPEs
Wire/cable
Seals
Flexible connectors

Trunk of a self steering vehicle

PHOTO: NEW YORK TIMES
• Wire/cable:
  - could grow from 2.4 km-4.0 km per vehicle
  - drive-by-wire could further increase demand
  - BUT wireless communication (via Wi-Fi could reduce amounts required)

• Flexible connectors: number of connectors will increase from 280 to 350 per vehicle

• Computers: average number per vehicle will increase from 26 in 2006 to 40 in 2018
  BUT computer function could centralize → reduced number of computers

• Shielding requirements will increase and become critical

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
APPROACHES TO INTERIOR ACOUSTIC CONTROL

- Acoustic headliner
- Polyolefin foam ducts in headliner
- Acoustic laminated windshield and front glass door
- Acoustic hood blanket
- Acoustic materials on both side of dash mat
- Fender to body sound baffles
- Acoustic wheelhouse liners

High damping foams (acoustic and anti-flutter function). Underbody(a)

Note: See some examples of acoustic approaches on GMC Yukon
(a) For example pumpable high damping foams (Teroson) from Henkel. Replace heavy bitumen sheets (weight save)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
 Modal analysis of midsize SUV, exited at front mounts

Control:  
No damping foam  
Standard anti-flutter

Frequency shift with pumpable high damping acoustic foam (Teroson from Henkel)

Damping foams can shift the resonant frequencies
Construction: DecoJect® thin foil
Fabrication process: Back injection; in-mold graining
Benefits:

Attraction feature
Durable soft-touch surface
Customizable
Processing advantages vs painting
Note: Example of trend toward translucent/transparent “windows”
Incorporate sensing/signal function?
### IMPROVEMENT TARGETS IN INTERIOR SKIN/FOAM
**BI-LAMINATES AND COATED FABRICS**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indentation recovery</td>
<td>Important for contact surfaces(a)</td>
</tr>
<tr>
<td>Laser score read-through</td>
<td>Almost all IP skins have converted to invisible passenger side driver-side airbags</td>
</tr>
<tr>
<td>Tailoring haptics(c)</td>
<td>Via controlling polyolefin foams/ surface coating</td>
</tr>
<tr>
<td>Performance requirements</td>
<td>- Abrasion resistance; Chemical resistance(b)</td>
</tr>
<tr>
<td></td>
<td>- Stain cleaning; Denim (blue dye cleanability)(e)</td>
</tr>
<tr>
<td>EU interior emissions req’ts</td>
<td>Becoming more severe(d)</td>
</tr>
<tr>
<td>Moving into hand wrap</td>
<td>Requires different stiffness/compression requirements</td>
</tr>
<tr>
<td>applications(a)</td>
<td></td>
</tr>
<tr>
<td>More leather-like look</td>
<td>Coated fabrics becoming competitive with leather</td>
</tr>
</tbody>
</table>

**Note:**
(a) Door trim panel, armrest, console cover
(b) NEP (N-ethyl pyrrolidone) resistance requirement being phased out in Europe (VDA standard)
(c) Via both surface touch coatings and foam modification
(d) Interior emission requirements are currently more severe than U.S. or Europe
(e) Requirements increased at GM/Ford 1-2 years ago (requires compromise between blue dye and coffee stain cleanability)

**SOURCES:** BENECKE KALIKO, TORAY, O’SULLIVAN
Trade name: Aquence® 5101 from Henkel

Application: laminating foil to substrate for IP, Door trim, others

Incumbent: 2K PU adhesives

Cure: blocked isocyanate, cures on command

Application: spray

Benefits: - aqueous system, low coating weight
  - long pot life (14 days), much longer than 2K systems
  - high temp resistance (105°C)
  - solvent free
  - no mixing

Typical coverage: 50 GSM

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
## SLUSH MOLDED TPE-S INSTRUMENT PANEL SKINS

<table>
<thead>
<tr>
<th>SKIN TYPE</th>
<th>SHARE (%)</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>25</td>
<td>Slush molding</td>
</tr>
<tr>
<td>TPO</td>
<td>50</td>
<td>Extrusion; Calendering; Thermoform</td>
</tr>
<tr>
<td>TPU</td>
<td>20</td>
<td>Spray; slush molding</td>
</tr>
<tr>
<td>TPE-S</td>
<td>-</td>
<td>Slush molding; potential new challenger</td>
</tr>
<tr>
<td>Leather/textile</td>
<td>5</td>
<td>Hand wrap; luxury vehicles</td>
</tr>
</tbody>
</table>

Photo: So.F.teR

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
SUMMARY

• Interiors: a major innovation zone: inter-materials/inter-process challengers

• New suppliers entering (Apple, Microsoft, Google): new technologies/functionality

• The major drivers/opportunity frontiers are:
  - weight save (new control/sensing modes (voice, light, motion, touch)
  - luxury look and feel (haptics)
  - process improvement: replace outdated component fabrication technology
  - role for 3D composite manufacturing: new materials/process combinations
  - electrical/electronic architecture
  - sensing technology and associated materials (thin film sensors)
  - acoustic improvement

• The major materials challengers are:
  - foams (several types including vibration damping foams to replace bitumen)
  - thermoplastic elastomers (TPEs)
  - new generation fillers/reinforcements (carbon fibers, graphenes, expanded graphene cellulosics)
  - improved conductive and “smart” materials