LIGHTWEIGHT COMPOSITES AND
NATURAL FIBERS IN AUTO INTERIORS

PRESENTED BY:
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PREPARED FOR:
PLASTICS IN AUTO INTERIORS
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HIGHLIGHTS

• AUTOMOTIVE ECONOMICS/EFFECTS ON COMPOSITES INDUSTRY STRUCTURE
• PERFORMANCE EFFECTS ON MKT POTENTIAL
• LIGHTWEIGHT COMPOSITES MARKET POSITION
• COMPETITION WITH NON-COMPOSITES
• INTRA-COMPOSITE COMPETITION
• INDUSTRY STRUCTURE SHIFTS
Automotive Interior Soft Trim:
Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers

Prospectus for a Global Multiclient Industry Analysis
Robert Eller Associates, Inc.

slide-covautoinsofttrim701 02.vsd
Opportunities for Advanced Technology
Nonwovens for Automotive Surface and Construction Applications in N. America and Europe

AUTOMOTIVE NONWOVENS AND TEXTILES MARKETS

COATED FABRICS
LEATHER
ARTIFICIAL LEATHER
WOVEN/KNIT TEXTILES
NEW LIGHTWEIGHT ACOUSTIC FIBERS

BATTING (SHODDY, FELT)
NONWOVEN FACINGS
FOAMS (COMPETITION/COMPLEMENT)
COMPOSITES COMPETITION FOR AUTOMOTIVE APPLICATIONS

NANO-TPOs, TPVs

LGF-PPs

MINERAL-FILLED TPOs

LTWT. FIBER MATS

AUTO INTERIORS/ EXTERIORS RIGID, FLEXIBLE, FOAMS

BIOPOLYMER RESINS

NFCs
OPERATING HYPOTHESES

• COMPOSITE TARGET CLASSES INCLUDE:
  – STRUCTURAL (XC BEAM, FLOOR, ROOF)
  – SEMI-STRUCTURAL (FLR MODULE, HL)
  – MECHANICAL
    – NON-STRUCTURAL (SEAT BACKS, DOOR TRIM)

• INTER-MATERIAL AND INTER-PROCESS COMPETITION

• ENERGY ABSORPTION IS A DRIVER

• INTEGRATION OF EA AND ACOUSTICS

• THERMOPLASTICS WHERE POSSIBLE

• WEIGHT SAVINGS INCENTIVES INCREASE

• SPACE SAVINGS ARE VALUED
OPERATING HYPOTHESES (CONT’D)

• NATURAL FIBERS CAN/WILL COMPETE
• NATURAL FIBER CHALLENGE TO GLASS FIBERS
• GROWTH OF “TALL CARS”: FLR MODULE GROWTH
• FLOOR MODULES: LARGER, MORE COMPLEX
• EUROPEAN FEM GROWTH: STIMULATE COMPOSITES
• COMPOSITES SUPPLY CHAIN CONSOLIDATION
• BIOMATERIALS ENTERING: FIBERS/MATRICES
• NANO-COMPOSITE TECHNOLOGY: N. AMERICA MORE ADVANCED
COMPOSITES FAMILIES

THERMOPLASTICS

GLASS MAT (GMTs)
- HIGH DENSITY (HD-RTPs)
- LOW DENSITY GLASS (LD-RTPs)

FIBER REINFORCED (FR-TPs)
- SHORT CARBON FIBER
- LONG GLASS (LGF-TPs)

SELF-REINF.
- COMP’D, M’BATCH
- DIRECT (D-LGF-TPs)
- PP MATRIX
- OTHER RESIN MATRIX

NATURAL FIBER THERMOPLASTIC COMPOSITES

HYDROCARBON BIOPOLYMER MATRIX
- WOOD FIBER
- BAST FIBER
- OTHER FIBER

MINERAL REINFORCED THERMOPLASTICS

CONV. FILLER (d)
- POLYOLEFIN MATRIX
- TPO PP

NANO FILLER (e)
- OTHER RESIN MATRIX (c)

THERMOSETS

GLASS CARBON REINF.
- NAT/SYN FIBER REINF. (a)

NOTES:
(a) e.g. WOOD FIBERS, OTHER CELLULOSICS, SYNTHETIC FIBERS
(b) e.g. COMPRESSION MOLDED WOOD/PHENOLICS OR COMPRESSION MOLDED REGENERATED FIBER MATS
(c) e.g. ENGINEERING THERMOPLASTIC (ETPs), TYPICALLY NYLONS
(d) e.g. CLAY, TALC, CALCIUM CARBONATE, SILICA, MICA, WOLLASTONITE
(e) e.g. CLAY (MOST COMMON), TALC (STARTING), SILICA, CARBON NANOTUBES
(f) e.g. PLA, PHA, OTHERS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004
AUTO INDUSTRY EFFECTS

• SLOW EMERGENCE FROM RECESSION?
• TIER 1 PROFITABILITY SQUEEZE
• GLOBAL PARTS SOURCING (CHINA)
• TIER 1 CONSOLIDATION: INCREASE PURCHASE POWER
• DOMESTIC OEM MKT SHARE LOSS
• HIGH VOLUME PLATFORM GROWTH
COMPOSITES SUPPLY CHAIN SHIFT

• BROADENED COMPOUNDER PROD. LINES
• FIBER/NANO-CONCENTRATES STARTING
• DIRECT COMPOUNDING GROWING
• NATURAL FIBERS, BIOPOLYMERS, NANO COMPETING
• MODULARIZATION: INTEGRATION VIA COMPOSITES
• COMPOSITES ENTERING NEW VEHICLE MODULES/FUNCTIONS
INTRA-COMPOSITE COMPETITION

• LD-RTPs VS. HD-RTPs: SEMI-STRUCTURAL
• NANO VS. CONVENTIONAL MINERAL FILLERS
• NANO VS. LGF-PPs
• NFCs VS. GF-TPs
AUTO COMPOSITES INDUSTRY
STRUCTURE SHIFTS

• HEAVY GMT SUPPLIERS ENTER LT WT GMT
• GLASS FIBER SUPPLIERS ENTER LGF-TP COMPOSITE PRODUCTION
• COMPOUNDERS ENTER NANO-COMPOSITE AND LGF-TP CONCENTRATES
• DIRECT COMPOUNDING OF LGF-TPs BY:
  – CUSTOM AUTO MOLDERS
  – BACK INTEGRATED TIER 1s
• ENTRY OF NATURAL FIBER PRODUCERS (SOME VIA BACK INTEGRATION BY AUTO OEMs AND TIER 1s)
• EMERGENCE OF BIOPOLYMER SUPPLIERS
COMPOSITES VS. OTHER CLASSES

• LD-RTPs IN WHEEL ARCH LINERS
• LD-RTPs VS. FOAM/SKIN LAMINATES (FLOOR)
• LD-RTPs VS. PU, PP FOAMS (H-LINER)
• NANO IN FUEL TANKS, SYSTEMS
• NANO VS. PVC: (BODY SIDE MOLDINGS)
• LD-GMTs AND LGF-TPs: NO COMPETITION
COMPOSITES TARGETS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004
LD-GMT THERMOPLASTICS (CONT’D)

• FMVSS 201
• INTEGRATION OF FOAM/ENERGY ABSORBING ELEMENTS INTO SUPPORT LAYER
• COMPETES W/ FOAM CORE SOLUTIONS
• REQUIRES ACOUSTIC PERFORMANCE
• INTEGRATES TEXTILES
• VARIETY OF TRIM OPTIONS
• HIGH PRIORITY ON SPACE CONSERVATION
• VALUE ADDED POTENTIAL
LOW DENSITY GLASS MAT THERMOPLASTICS (LD-GMT)

• GENERATION 1 HIGH DENSITY GMTs DECLINING
• LD-GMTs IN GROWTH STAGES (DOOR TRIM, INSTRUMENT PANEL, HEADLINER, FLOOR)
• CHALLENGE TO INJECTION MOLDING IN INSTRUMENT PANEL & DOOR TRIM HARDWARE MODULE
• NATURAL FIBERS ENTERING
• INCREASED NUMBER OF SUPPLIERS
## INTRA-COMPOSITE COMPETITION

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>THERMOPLASTIC COMPOSITE CANDIDATES</th>
<th>LD-RTP</th>
<th>HD-GMT</th>
<th>SGF-TP</th>
<th>LGF-TP</th>
<th>HC-NFC</th>
<th>MIN-TP</th>
<th>NANO-TP</th>
<th>OTHER (a)</th>
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<tr>
<td>ACOUSTIC BARRIERS</td>
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<td>DOOR MODULES</td>
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<td>IN MOLD DECORATION</td>
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### INTRA-COMPETITION FOR AUTOMOTIVE APPLICATIONS (CONT’D)

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<tr>
<th>APPLICATIONS</th>
<th>THERMOPLASTIC COMPOSITE CANDIDATES</th>
<th>OTHER (a)</th>
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<tr>
<td></td>
<td>LD-RTP</td>
<td>HD-GMT</td>
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<td>INTERIOR SKINS</td>
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<td>IP SUBSTRATES</td>
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<td>MECHANICAL COMPONENTS</td>
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<tr>
<td>ROCKER PANELS</td>
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<td>RUNNING BOARDS</td>
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<td>STEP PADS</td>
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<tr>
<td>WHEEL ARCH LINER</td>
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**NOTES:**

(a) OTHER INCLUDES NON-COMPOSITE COMPETITION FROM:
- FOAMS - UNFILLED POLYMERS (PRIMARILY ETPs, PVC)
- NONWOVENS - METAL/PLASTIC HYBRIDS
- FOAM/SKIN LAMINATES - REGENERATED FIBER MATS (SHODDY)
- THERMOSETS (PU, PET)

(b) HD-GMTs HAVE LOST SHARE IN FEMs
## COMPARISON OF LD-GMTs AND LGF-PPs

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>LGF-TP</th>
<th>LD-GMT</th>
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<tbody>
<tr>
<td>DENSITY, GSM</td>
<td></td>
<td>LOWER, 700-2000 (a)</td>
</tr>
<tr>
<td>TOOLING COST</td>
<td></td>
<td>LOWER (b)</td>
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<tr>
<td>TYPICAL PROCESS</td>
<td>INJECTION, COMPRESSION</td>
<td>COMPRESSION, THERMOFORMING</td>
</tr>
<tr>
<td>TYPICAL GLASS CONCENTRATION, %</td>
<td>40, 32</td>
<td>40-55%</td>
</tr>
<tr>
<td>DIRECT/COMPOUND/ FABRICATION POSSIBLE</td>
<td>YES, COMMON</td>
<td>YES, POSSIBLE; NOT COMMONLY USED</td>
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<tr>
<td>TYPICAL PART</td>
<td>COMPLEX</td>
<td>SIMPLE</td>
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<tr>
<td>PART SIZE</td>
<td>SMALL</td>
<td>LARGE</td>
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<tr>
<td>PART THICKNESS</td>
<td>THICKER</td>
<td>THINNER</td>
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### COMPARISON OF LD-GMTs AND LGF-PPs (CONT’D)

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<tr>
<th>PARAMETER</th>
<th>LGF-TP</th>
<th>LD-GMT</th>
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</thead>
<tbody>
<tr>
<td>USE IN LAMINATES</td>
<td>USUALLY NOT</td>
<td>YES (‘c)</td>
</tr>
<tr>
<td>EXAMPLE APPLICATION</td>
<td>MECHANICAL (d), SEMI-STRUCTURAL (e)</td>
<td>WHEEL ARCH LINER HEADLINER (f) UNDERBODY SHIELDS</td>
</tr>
<tr>
<td>LOAD BEARING CAPACITY</td>
<td>HIGHER</td>
<td></td>
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</table>

**NOTES:**
(a) LD-GMTs CAN BE LOFTED TO REDUCE DENSITY
(b) ALUMINUM OR EPOXY TOOLS CAN BE USED
(c) FOR EXAMPLE IN FLOOR MODULES
(d) E.G. DIE CAST METAL REPLACEMENT
(e) E.G RUNNING BOARDS (NANO-COMPOSITES COMPETE IN THIS APPLICATION)
(f) ALSO OTHER INTERIOR SEMI-STRUCTURAL APPLICATIONS

**SOURCE:** ROBERT ELLER ASSOCIATES, INC., 2004
HEADLINER CORE

• FOAM VS. COMPOSITE BATTLEGROUN
• LD-GMTs HAVE PENETRATED
• ENERGY ABSORPTION REQ’D (FMVSS 201)
• ACOUSTIC PERFORMANCE REQUIRED
• ON BOARD EA, ACOUSTICS STARTING
• TEXTILE INTEGRATION START?
• NEW SUPPLY CHAIN PARTICIPANTS ENTER
• SPACE CONSERVATION VALUED
• A VALUE ADDED TARGET
RIGID SEMI-STRUCTURAL FOAM SANDWICH FLOOR STRUCTURE

MAY BE COLLAPSED TO FORM INTEGRAL HINGE

CARPET/NONWOVEN/WOVEN TEXTILE LAMINATE:

NOTE:
(A) MAY ALSO BE EXTRUDED FOAM SHEET (E.G., FAGERDALA XPP)

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2005
LONG GLASS FIBER THERMOPLASTICS

• FEMs (VS. HYBRIDS AND HD GMT)
• RUNNING BOARDS (VS. NANO COMPOSITES)
• DOOR MODULE (VS. SGF-PP, ETP, NFCs)
• LOAD FLOORS (VS. LD GMTs, FOAM SANDWICHES)
• IP SUBSTRATES
• DIRECT COMPOUNDING STARTING
## NANOCOMPOSITES TARGETS

<table>
<thead>
<tr>
<th>TARGET</th>
<th>KEY PROPERTIES</th>
<th>STATUS</th>
<th>NOTE</th>
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<tbody>
<tr>
<td>EXTERIOR:</td>
<td></td>
<td></td>
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<tr>
<td>BODY PANEL</td>
<td>STIFFNESS, PAINTABILITY, THIN WALL</td>
<td>SEVERAL AT GM</td>
<td>HIGH GROWTH POT’L</td>
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<tr>
<td>GLAZING</td>
<td>LIGHT TRANSMISSION SCRATCH RESISTANCE</td>
<td>EXTENSIVE PRIOR DEVELOPMENT</td>
<td>TARGET FOR GE/EXATEC</td>
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<tr>
<td></td>
<td>WEATHERABILITY</td>
<td></td>
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<tr>
<td>BUMPER REINFORCEMENT BEAM</td>
<td>STIFFNESS, IMPACT</td>
<td>CONCEPT</td>
<td></td>
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<tr>
<td>STEP/RUNNING BOARDS</td>
<td>STIFFNESS</td>
<td>STARTED ON GM VANS IN 2002</td>
<td>GROWTH APPLICATION FOR LG-PP</td>
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<tr>
<td>MIRROR HOUSING</td>
<td>WEATHERABILITY, PAINTABILITY, IMPACT</td>
<td>ABANDONED</td>
<td>TOO EXPENSIVE VS. INCUMBENT</td>
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### NANOCOMPOSITES TARGETS (CONT’D)

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<tr>
<th>TARGET</th>
<th>KEY PROPERTIES</th>
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<th>NOTE</th>
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<tr>
<td>INTERIOR:</td>
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<tr>
<td>FIBERS</td>
<td>LOW DENIER</td>
<td>TORAY INTRODUCTION</td>
<td>NANO-CARBON</td>
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<td>STRUCTURAL SEAT BACK</td>
<td>IMPACT</td>
<td>STARTED AT HONDA</td>
<td>EUROPEAN “BEER CRATE” LEGISLATION WILL DRIVE</td>
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<tr>
<td>SIDE IMPACT BEAM</td>
<td>IMPACT, STIFFNESS</td>
<td>CONCEPT</td>
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<td>TRIM</td>
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<td>CONTRACT IN PLACE</td>
<td>EUROPE</td>
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NANOCOMPOSITES TARGETS (CONT’D)

<table>
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<th>KEY PROPERTIES</th>
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<th>NOTE</th>
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<td>UNDERHOOD/FUEL</td>
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<td>FUEL TANK</td>
<td>BARRIER</td>
<td>GROWTH WITH THERMOFORMING</td>
<td>REPLACE EVOH?</td>
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<td>FUEL LINE</td>
<td>BARRIER</td>
<td>COMMERCIAL IN JAPAN</td>
<td>EARLY APP IN NYLON NANO-ACETAL (JAPAN)</td>
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<td>ENGINE COVER</td>
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<td>MITSUBISHI ON GDI MODELS</td>
<td>POOR IMPACT RESULTS AT BASF</td>
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<td>TIMING BELT COVER</td>
<td>HEAT RESISTANCE</td>
<td>ABANDONED</td>
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</table>

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004
NATURAL FIBER COMPOSITES (NFCs)

- WOOD FIBERS WIDELY USED
- BOTH HYDROCARBON AND BIOPOLYMER MATRICES
- SYNTHESIZED BIOPOLYMERS STARTING
- BROAD FIBER RANGE POSSIBLE
- BOTH MAT AND MOLDED PARTS
- COMPETE WITH NANO AND GLASS FIBERS?
BIOPOLYMER CANDIDATES FOR AUTOMOTIVE APPLICATIONS

BIOPOLYMERS

MATRIX

HC-BASED (E.G., PP)

BIOPOLYMER

-PLA

-SOY

FIBERS

NATURAL

VEGETABLE

ANIMAL (E.G., WOOL, HAIR)

MINERAL

CARBON

SYNTHETIC

HC-BASED

BIO-BASED (BIOFIBERS)

FIBERS

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SYNTHETIC

HC-BASED

BIO-BASED (BIOFIBERS)

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

re/mydox/Nissan/Nissan-auto biopolymer 04.vsd
lg/myfiles/visio/Nissan-auto biopolymer 04.vsd
NATURAL FIBER COMPONENTS IN MERCEDES C-CLASS
CONSTRUCTION OF NONWOVEN WHEEL ARCH LINER

- NEEDLEPUNCHED NONWOVEN (ZANEVIL(a)); ANTIVIBRATION AND SOUNDPROOFING
- EXTRUDED MID-LAYER (PP, EPDM?) (AFONTEX(a))
- NEEDLEPUNCHED NONWOVEN(b)

FACING TIRE

NOTES:

(a) PROPRIETARY BRAND FROM SAN VALERIANO

(b) FIBERS ARE VERTICALLY ALIGNED

SOURCE: SAN VALERIANO

b/mydox/nwmc/nw04-wheel arch liner 04.vsd
lg/myfiles/visio/nw04-wheel arch liner 04.vsd
MERCURY MARINER --

- HARD ABC PILLAR
- VISIBLE PASSENGER AIRBAG DOOR
- KNITTED HEADLINER
- HARD DOOR TRIM PANEL (CLOTH INSERTS)
- HARD INSTRUMENT PANEL
- METAL TRIM ON CONSOLE

- SHODDY ACOUSTIC BATTING
- HARDBOARD/EPP FOAM STC
EXAMPLE OF BACK MOLDED PILLAR TRIM

TEXTILE PENETRATION INTO PLASTIC

REVERSE SIDE OF TEXTILE

SOURCE: FREUDENBERG, REA PHOTOS
EXAMPLE OF BACK MOLDED PILLAR TRIM WITH NONWOVEN TEXTILES

FLEXIBLE 2-SHOT MOLDED GASKET

SOURCE: FREUDENBERG, REA PHOTOS
EXAMPLE OF NONWOVEN TEXTILE (MICROFIBER SUEDE) IN LUXURY TEXTILE APPLICATION

SOURCE: ALCANTARA 2004
SUMMARY

• AUTO PRICE PRESSURES:
  – COMPOSITES INTO LARGER MODULES
  – VALUE ADDED OPPORTUNITIES
  – COMPOSITE SUPPLY CHAIN SHIFT

• COMPOSITE OFFERINGS BROADENING

• RANGE OF PERFORMANCE LEVELS

• INTRA-COMPOSITE COMPETITION

• EXPANDED PROPERTY ENVELOPE