

# NOMEX® and KEVLAR® for Rail Applications

## Parallels between Aerospace and Rail

### DuPont Protection Technologies

*Railway Interiors Expo, Koelnmesse,  
Germany, 26 November 2006*



***Olivier Rozant, PhD*** – Development Manager KEVLAR®, NOMEX® Mass Transportation



*The miracles of science™*

# Agenda

- **Nomex® Honeycombs for Rail Applications**
  - **Characteristics for transportation industry**
  - **Parallels between aerospace and rail**
  - **Applications and benefits**
    - **Structural**
    - **Interiors and design**
    - **Manufacturing**
- **Conclusions**



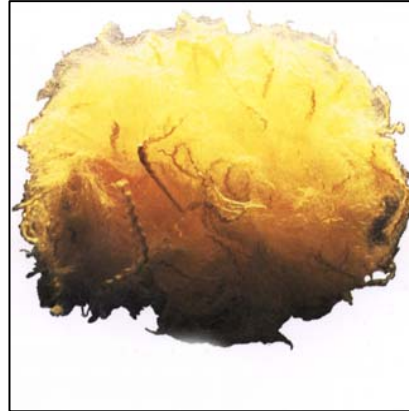
# Nomex® - Characteristics for Transportation Industry

*“Nomex® - the qualities you need in mass transportation”*

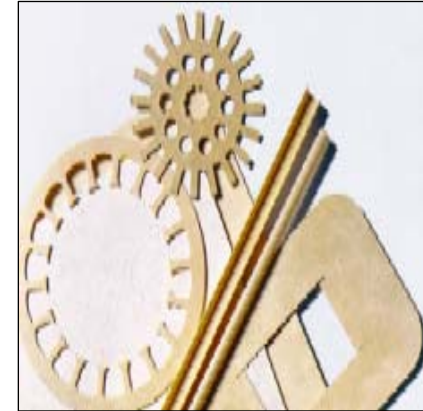
## Filament Yarn



## Staple Fiber



## Paper & Board



### HEAT RESISTANT

- Self auto-extinguishable
- Does not shrink under heat
- Does not melt / drip
- Starts to carbonize at 425°C to 475° C
- Good heat insulator
- Electrical arc resistance

➤ **Constant quality of production**

### ABRASION RESISTANCE

- 2 times more abrasion resistant than cotton
- Up to 4 times more tear resistant than cotton

### CHEMICALLY RESISTANT

- Resistant to a wide list of chemicals
- Water and oil do not affect the properties

### FLEXIBLE

- Wearing comfort

# Nomex® - Characteristics for Transportation Industry

## Personal Protection



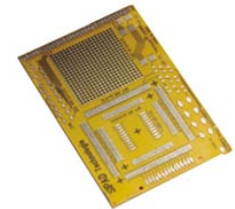
## Electrical Insulation in Transformers & Motors



## Thermal Barriers



## Electronics



## Gas Filtration



## Composites



## Flame Resist Fabrics





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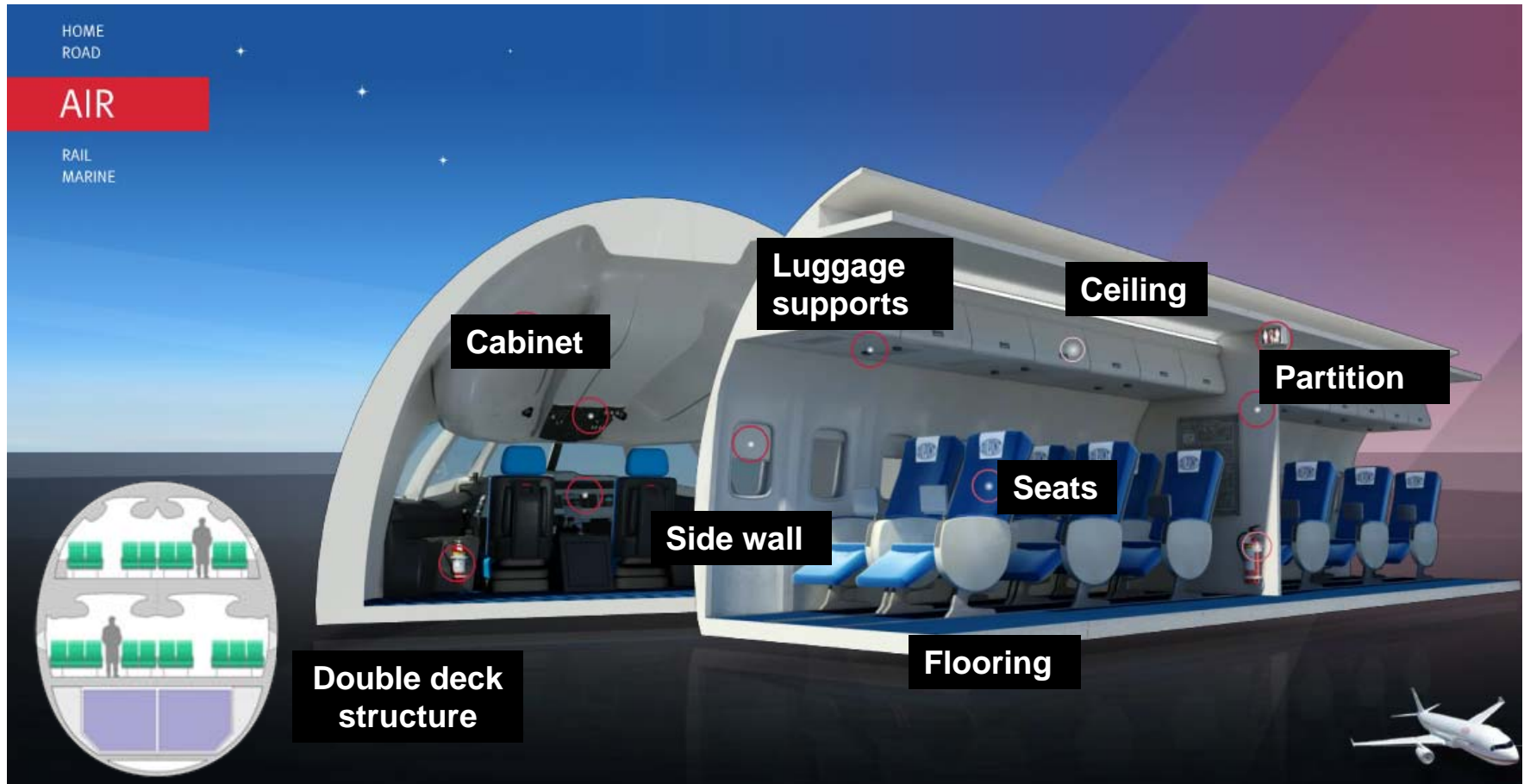
# Nomex® - Parallels between Aerospace and Rail



## Aerospace and Rail have same requirements:

- Mass transportation
- Stringent safety / fire regulations
- Product performances reliability
- Improved efficiency for energy savings
- Enhanced passenger comfort
- Efficient and smart manufacturing

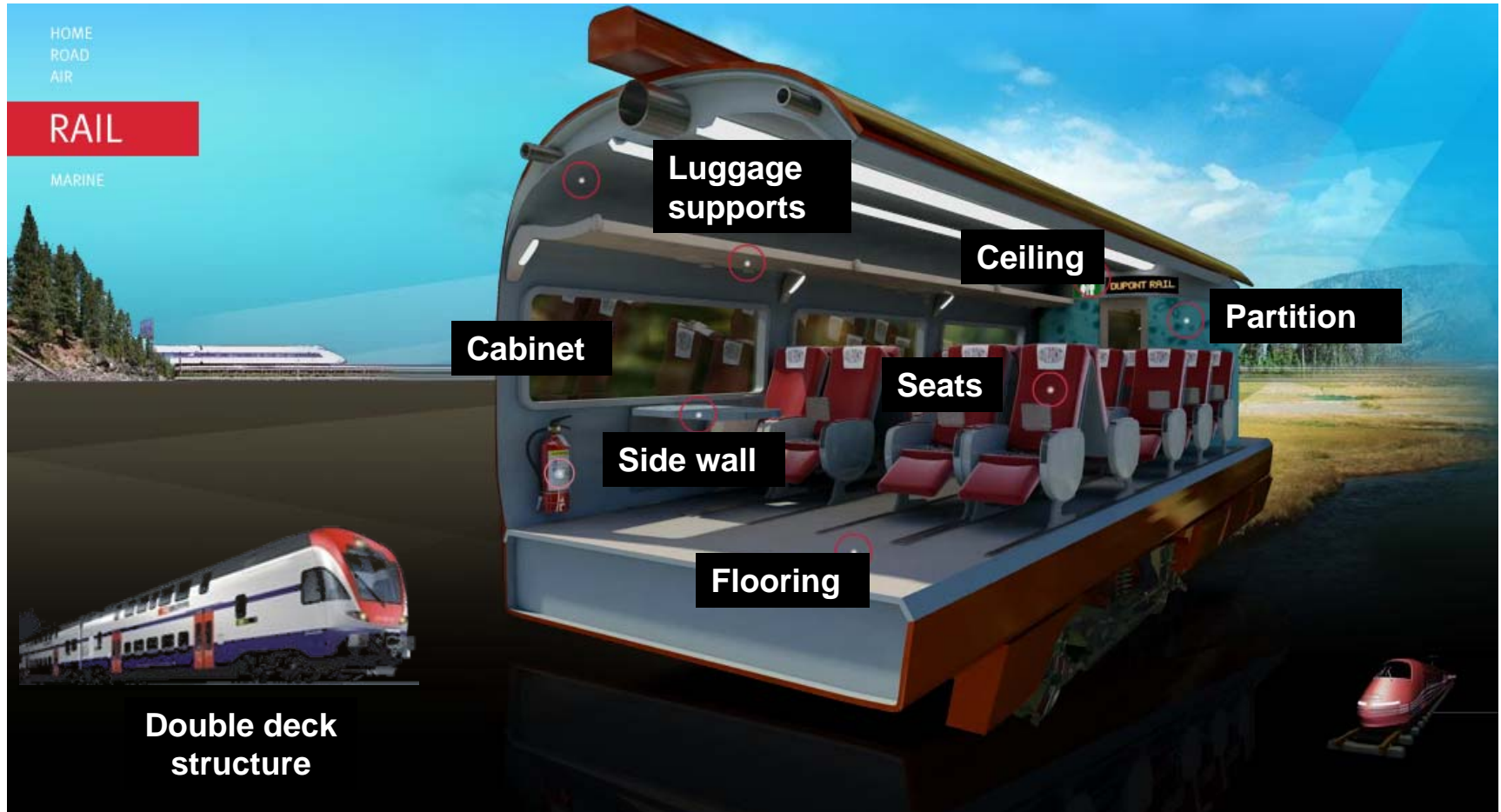
# Nomex® - Parallels between Aerospace and Rail



## Parts where Nomex® is used in aircrafts

- Under **honeycombs** for structural / semi-structural parts
- Under **protective fabrics** for its fire resistance

# Nomex® - Parallels between Aerospace and Rail



## Aerospace and Rail have same requirements:

- Similar interiors
- Similar performances and functionalities

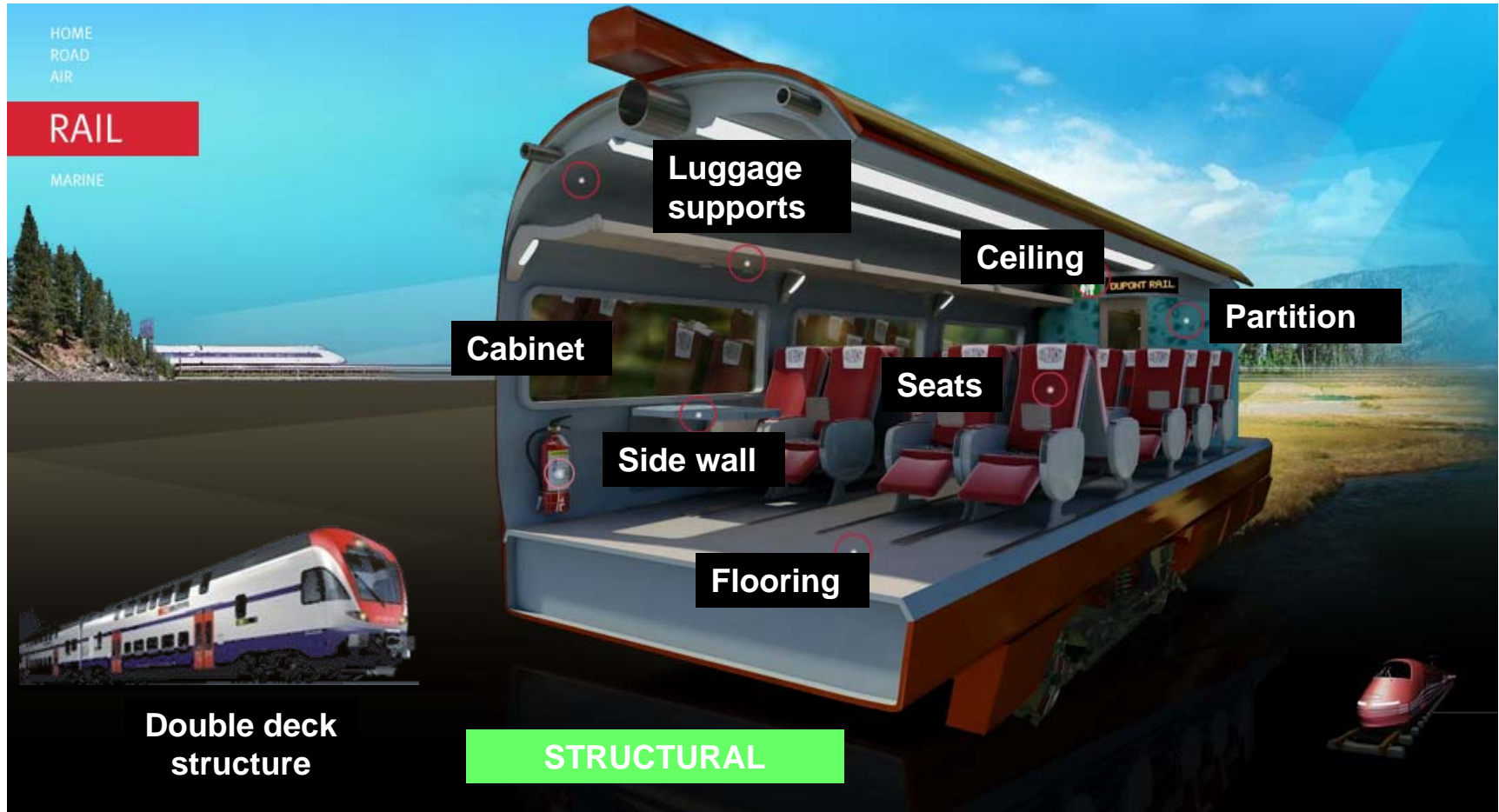


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# Nomex® - Applications and Benefits



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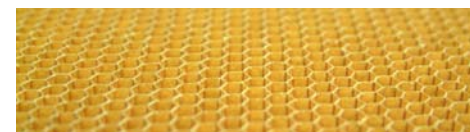
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# Nomex® - Applications and Benefits

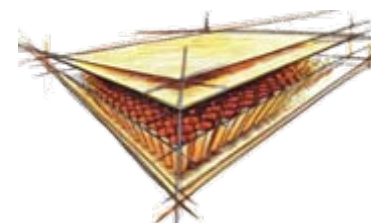
*“Nomex® - the qualities you need in mass transportation”*

## Honeycomb cores

- Exceptional stability of stiff hexagonal cells **inspired by nature**
- Honeycomb is a **smart core**
  - **Light**
  - **Strong**
  - **Rigid (sandwich)**
- **Nomex® honeycombs** bring added benefits:
  - **Excellent moisture resistance** = neither fungi nor mold
  - **Chemically inert and non-metallic** = **inherently corrosion resistant**
  - **Heat and flame resistance + self-extinguishing** properties = meet stringent aircraft standards approved in aircrafts
  - **Absorbs noise and vibration** (engine, rolling noises) = enhanced comfort for passengers



Nomex® honeycomb



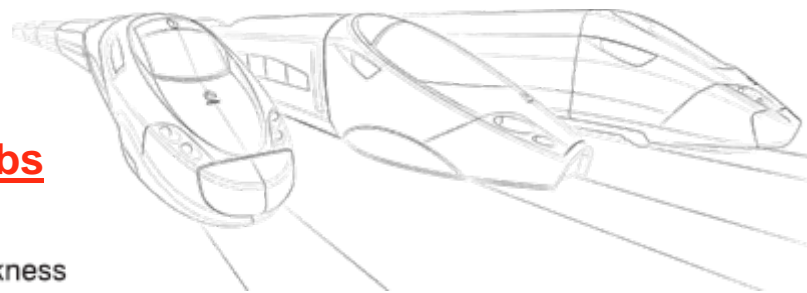
Sandwich structure



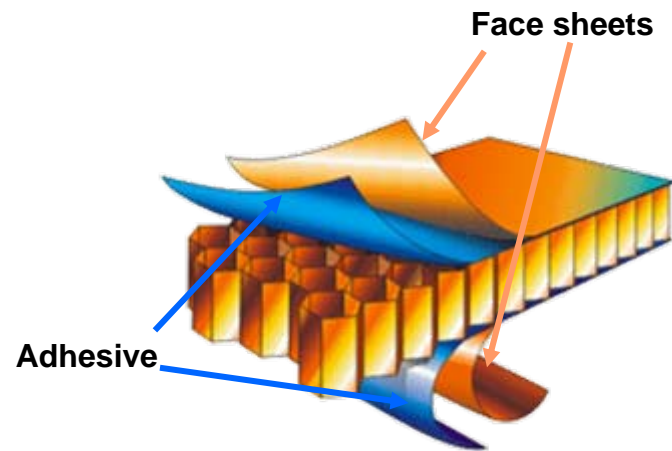
26 Nov. 2009, Railway Interiors, Koeln

# Nomex® - Applications and Benefits

*“Nomex® - the qualities you need in mass transportation”*


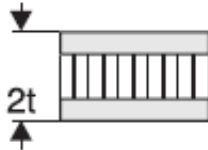
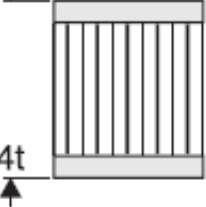


Lightening your loads with smart design



Honeycomb sandwich construction

## Sandwich effect with honeycombs

	Solid Material	Core Thickness $t$	Core Thickness $3t$
			
Stiffness	1.0	7.0	37.0
Flexural Strength	1.0	3.5	9.2
Weight	1.0	1.03	1.06

Statistics courtesy of Hexcel

- **Nomex® honeycomb** stiffens and strengthens a structure **without increasing its weight**





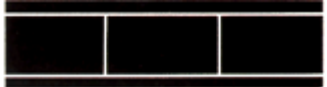




# Nomex® - Applications and Benefits

*“Nomex® - the qualities you need in mass transportation”*



## Structural comparisons for bending loads

Design	Relative strength	Relative stiffness
 Honeycomb Sandwich	100 %	100%
 Foam Sandwich	26	68
 Structural Extrusion	62	99
 Sheet and Stringers	64	86
 Plywood	3	17

*Statistics courtesy of Hexcel*

## Maximum robustness for minimum weight

- **Shear strength**
  - >> foams / balsa / plywood
  - ~ aluminium and glass honeycombs
- **Compressive strength**
  - slightly better than aluminium and wood
  - >> better than rigid foams
- **Toughness** (vs other honeycomb cores)
  - **unique capability** to resist overloads in local areas without permanent damage
  - provide **excellent in-service abuse resistance**

# Nomex® - Applications and Benefits

## Nomex® cored sandwich structures in structural applications

### Benefits

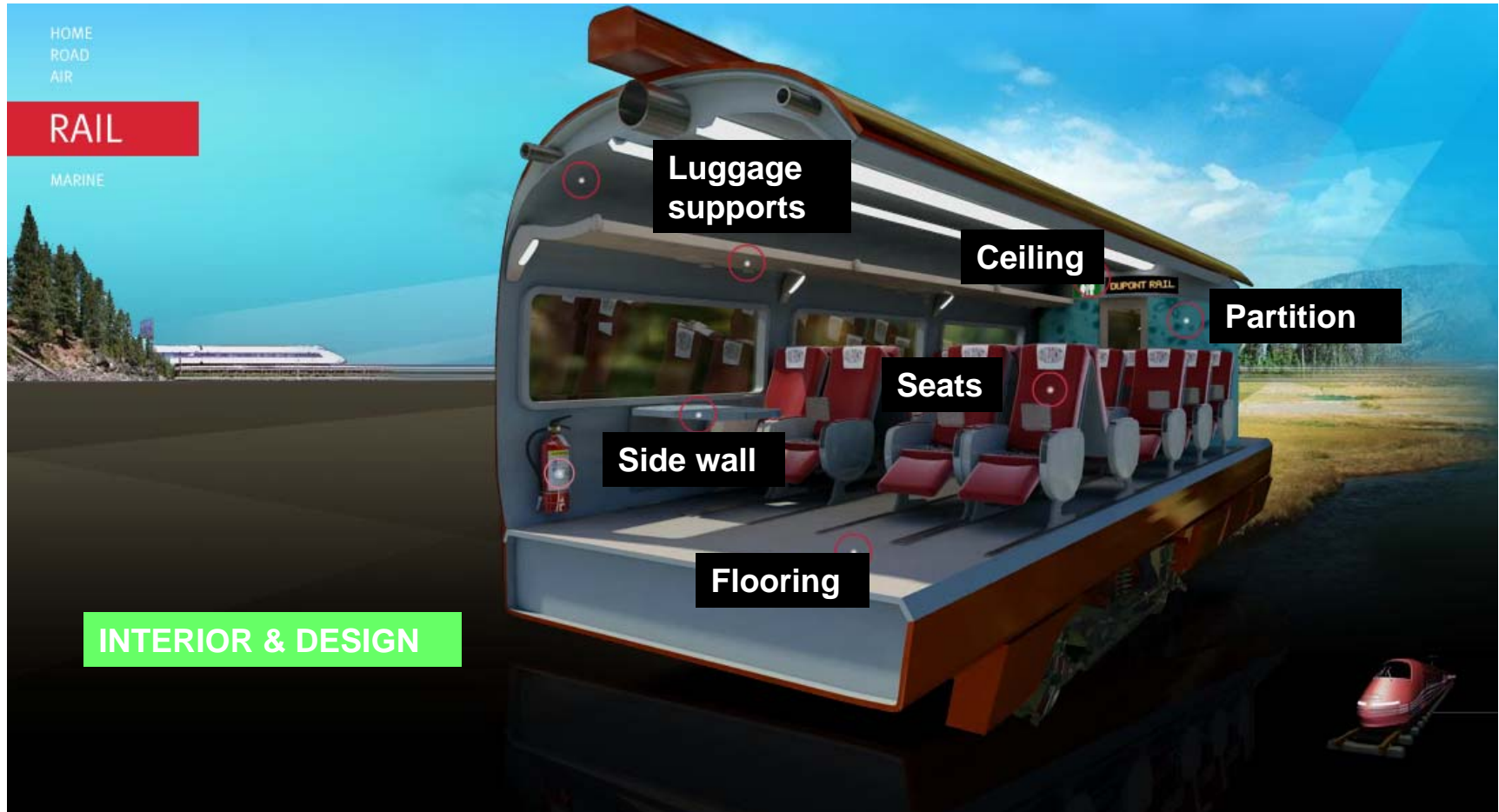
- **Lower weight**
  - Lighter coaches for **improved efficiency** (E, CO<sub>2</sub> credits)
  - **Lower center of gravity** for greater safety and comfort (high-speed, double-decker trains)
  - **Lower inertia** resulting in significant **energy savings** (inter-city, metros, trams)
  - **Lower stresses** reduce **bogie** maintenance
  - **Less wear** and damages on **tracks** for **increased service life**
- **Higher specific stiffness**
  - **Less partitions** and **more interior design flexibility**
  - **Additional seats** or payload capability
- **Intrinsic to Nomex®**
  - Unique **vibrations** and **noise damping** for **better comfort**
  - Better **thermal insulation** – (~ 180 x / Al)



Photo courtesy of Alstom, Bombardier

# Nomex® - Applications and Benefits

## *Parallels between Aerospace and Rail*



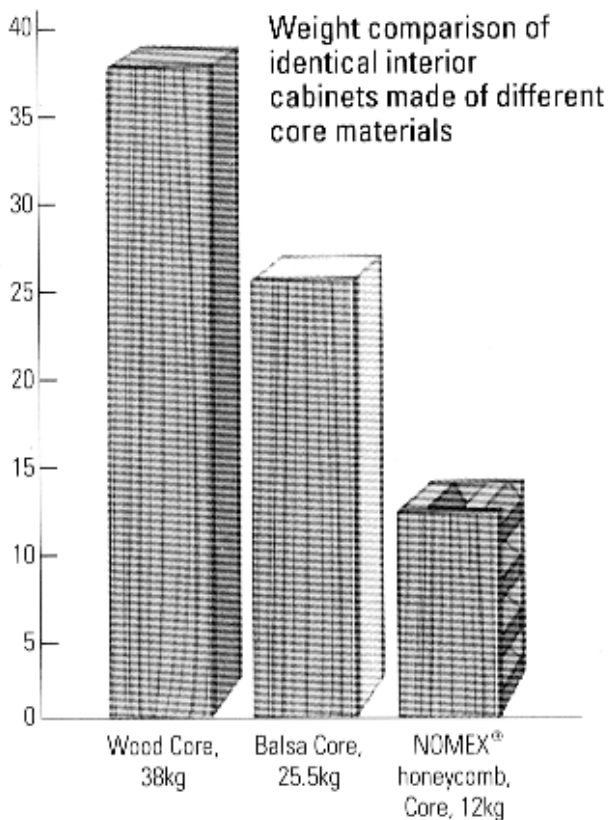
### Aerospace and Rail have same requirements:

- Similar interiors
- Same requirements and functionalities

# Nomex® - Applications and Benefits

*“Nomex® - the qualities you need in mass transportation”*

## Interiors and decorative solutions



- **Low weight – 60% lighter than all-wood equivalents**
- **Easy to shape** (thermoformable – cells do not collapse)
- Dimensional stability
- **Extremely impact tolerant**
- **Fire resistant** – non-melting, self-extinguishing & low smoke emission
- **Sound, vibration and heat insulation** (enhanced comfort)



Photo courtesy of IFV, TER, Alstom

26 Nov. 2009, Railway Interiors, Koeln



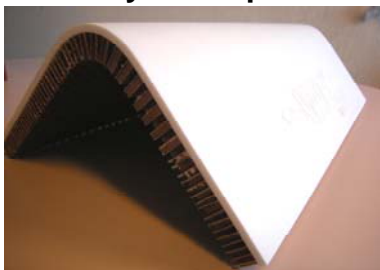
# Nomex® - Applications and Benefits

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## Interiors and decorative solutions



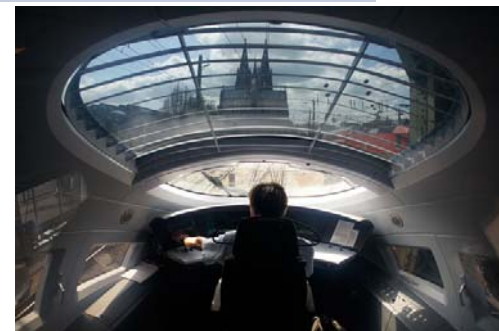
Easy to shape



- Let our imagination be your guide
  - Interior furnishing, **partitions**, cupboards,...
  - Staterooms, **cabins**, galleys and bathroom
  - **Tables**, bunks, decks and bulkheads
  - **Doors**, hatches, **ceiling panels** and stairwells

- Additional functionalities

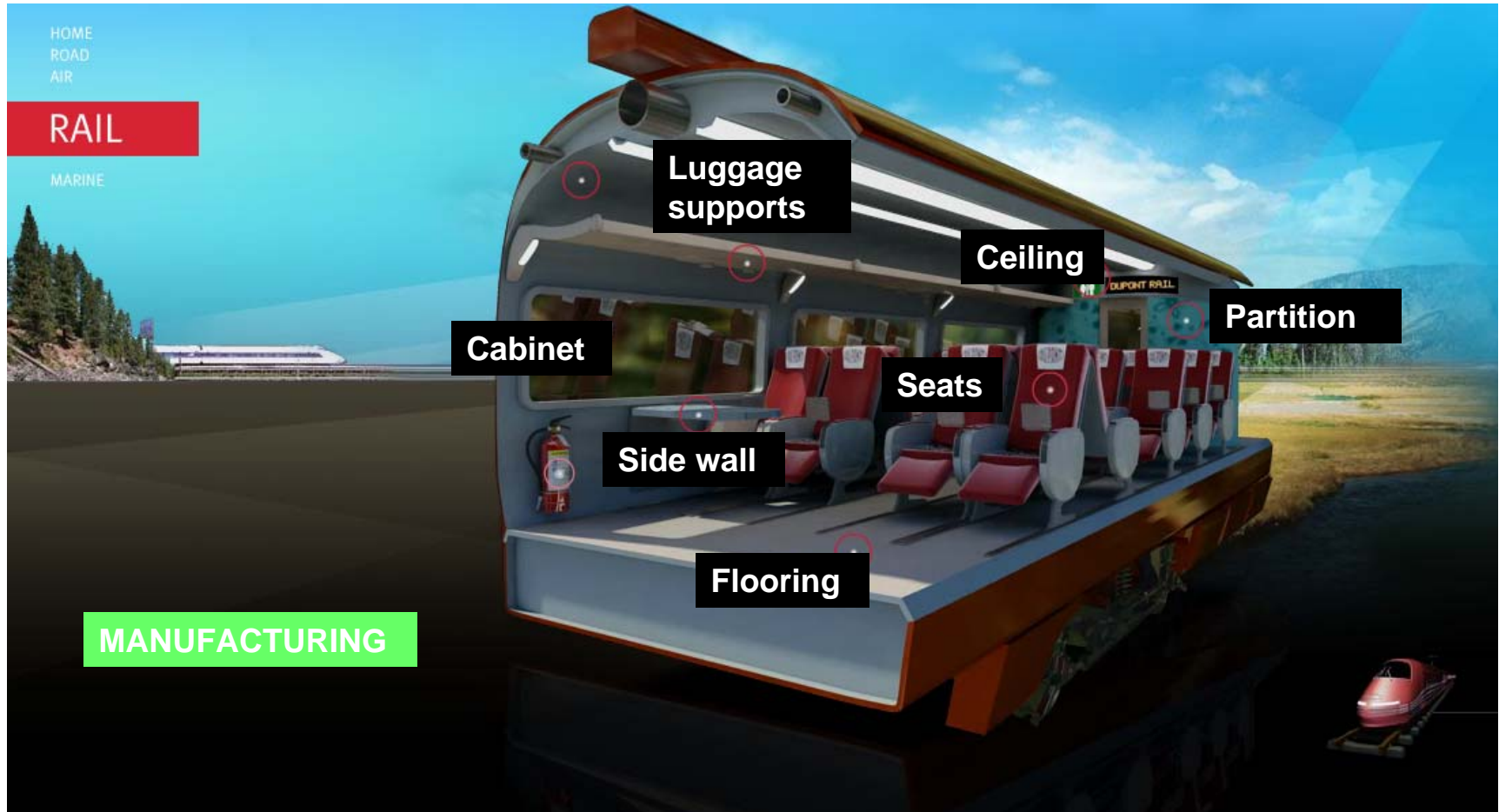
- **Insulation** and **fire resistance**
- Compatible with **Corian®** for **nicer, cleaner and colored surfaces** to beat competition (restaurant coach, lavatories, kitchen)



*Photo courtesy of Bombardier, Alstom*

# Nomex® - Applications and Benefits

## *Parallels between Aerospace and Rail*



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# Nomex® - Applications and Benefits

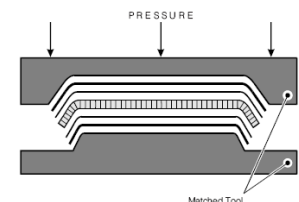
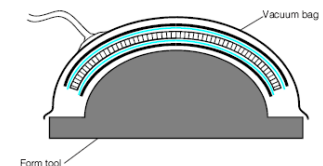
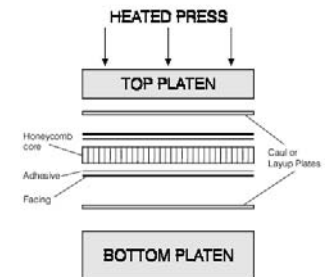
*“Nomex® - the qualities you need in mass transportation”*

## Fabrication of Nomex® cored sandwich structures

- 3 conditions should be met
  - **Tooling and fixtures** must maintain the desired shape
  - **Uniform pressure** must be applied to hold the structure together during curing
  - **Uniform heating** must be used to cure the resin
- 3 alternative well-established production methods
  - **Heated press** – for flat boards or simple preformed panels
  - **RTM / vacuum processing** - for **large** or complex form **panels**
  - **Matched mould processing** – for batch production of finished panels



Photo courtesy of Stadler



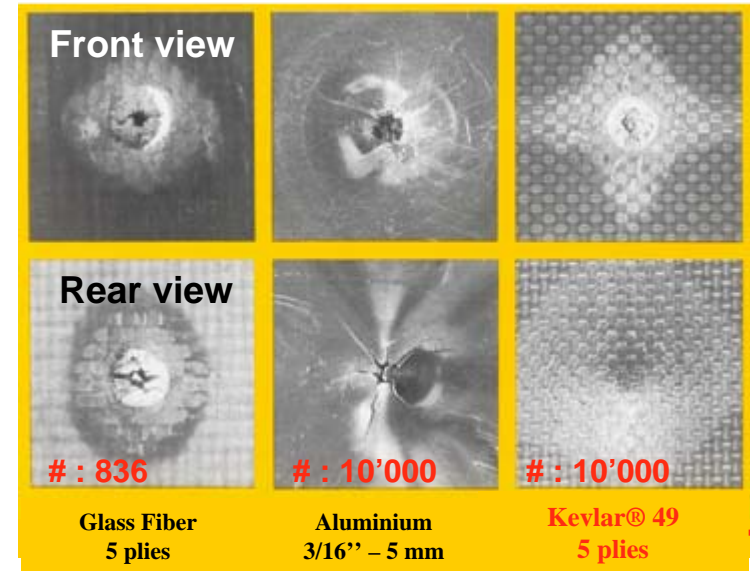
# Nomex® - Applications and Benefits

## Fabrication of Nomex® cored sandwich structures

### Benefits

- From conventional assembly to composites route:
  - **Less holes / bolts** (-40% tensile / -15% compression strength locally) for **stronger and reliable parts**
  - **More bonding** for **less stress concentration**
  - Consolidation of manufacturing with much **fewer parts**
  - Advanced **Nomex® honeycombs** suitable for RTM for **improved manufacturing efficiency** especially for **large parts** (flooring, ceiling, side-walls,...)
  - Can be combined with **Kevlar® face sheets** for **improved impact resistance** (ballast, hail, maintenance, vandalism,...) resulting in **longer life cycle** and **reduced maintenance**
  - Some **Kevlar® fabrics** are especially adapted for **RTM**

### Panel toughness comparison (number of repeated impacts)



**Tough, impact resistant, puncture resistant, inherent resistance to abrasion, environmental degradation resistant, corrosion free, heat / electrical insulator, vibrations / sound damping, safety, ruggedness, reliability**



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# Nomex® (and Kevlar®) for Transportation Industry

## CONCLUSIONS

### Benefits for Mass Transportation Industry

Properties	Benefits
Low density	Weight savings for increased payload, energy savings. Assists structural weight management.
High strength & stiffness	Robustness, dimensional stability under load
Impact resistance	Durability; safety
Electrically non-conductive	No galvanic corrosion; increased durability; radio transparency
Low thermal expansion	Dimensional stability
Vibration damping	Enhanced durability
Thermal insulation	Energy conservation, comfort
Resistant to heat and flames	Safety
Good weatherability	Long-term exterior use

- **Exceptional combination of many desirable engineering properties** opens many opportunities for new and better products especially for the highly weight-conscious field of transportation



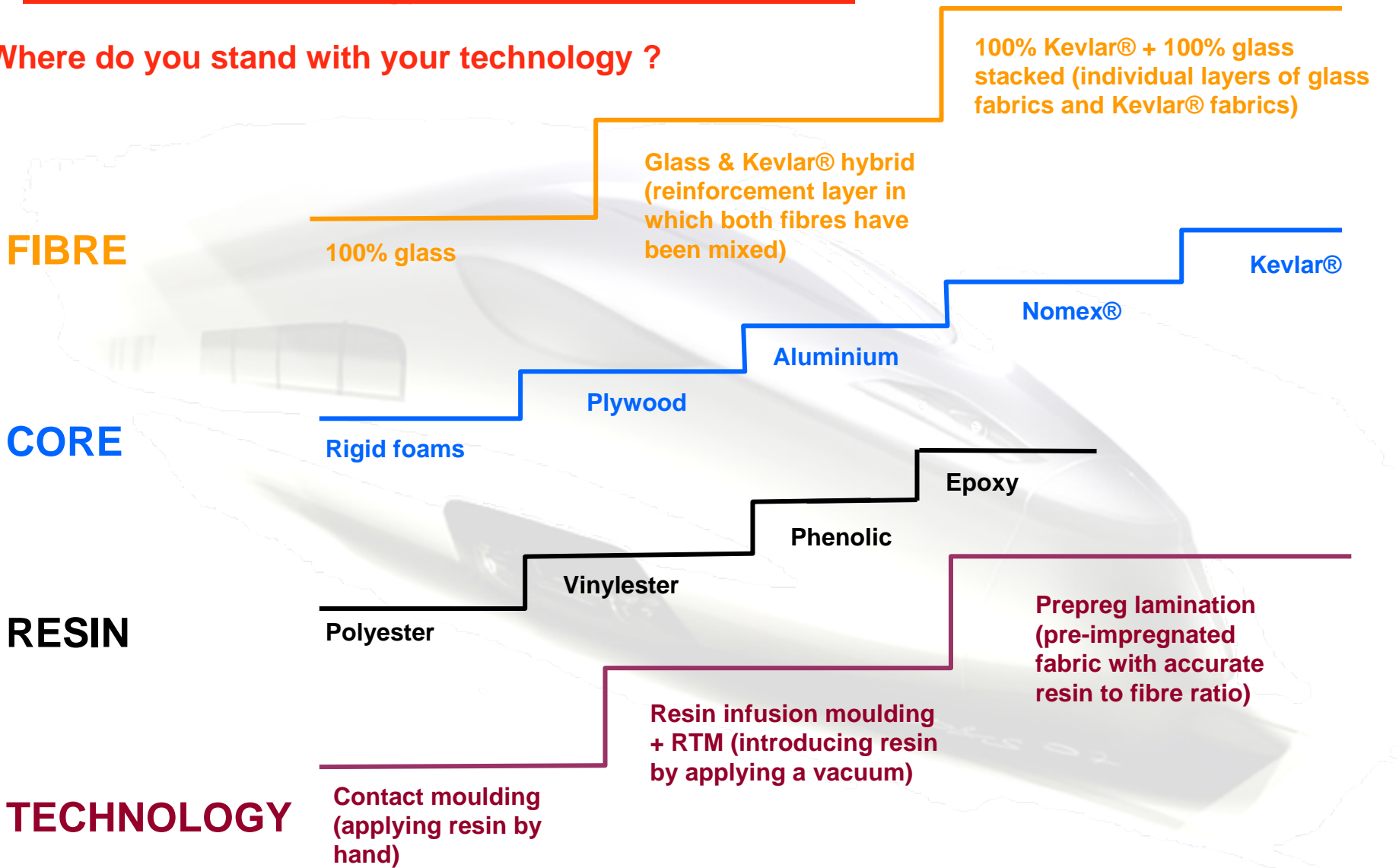
As a **leading science company**, **DuPont** is a **partner of choice** with its sustainable & technology driven solutions. Bringing together high performance, aesthetics and safety, DuPont is meeting the needs of the rail industry today.



# Nomex® (and Kevlar®) for Transportation Industry

## ➤ Composite technology ladder in MT Production

Where do you stand with your technology ?





*The miracles of science™*

[www.dupont.com](http://www.dupont.com)



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