

# Urban Air Mobility Solutions

How rigid foam cores will contribute to eVTOL production

Analli Carvalho and Alexander Roth

# No product is so perfect that you can't improve it.

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more fuel-efficient



**TIRES**

fluffier



**TOWELS**

bouncier



**MATTRESSES**

healthier



**NUTRITION**

more effective



**TABLETS**

To make that happen,  
we go beyond

# CHEMISTRY

# That's specialty chemicals. And that's where we're among the best in class.

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**> €15 billion**

sales\*

**€2.4 billion**

adjusted EBITDA\*

**€1.17**

dividend per share\*\*

**15.9%**

adjusted EBITDA margin\*

**~80%**

of sales from  
leading market positions

**€929 million**

investment in tangible assets

**>33,000**

employees

**106**

nationalities

**€2.12**

adjusted earnings  
per share\*

\* Fiscal 2021, ongoing activities

\*\* Proposal to the Annual General Meeting in May 2022

# Air Taxis surged as an answer for Urban Mobility societal and economical issues.

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**Congestion** by 2023 the macroeconomic cost of congestion in US and Europe is estimated 300 billion.

**CO2 emission** in transportation vehicles.



**Fast, quiet and cheaper** transportation compared to helicopters.

**Sustainable**, battery powered, electrical take off and landing, carbon neutral transportation.



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# Urban Air Mobility surged as an answer for Urban Mobility issues.

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Air Taxi

Flying car

Urban Air Mobility - UAM

Advanced Air Mobility - AAM

eVTOL

Electrical

Vertical

Take

Off and

Landing



Bryce Durbin / TechCrunch

Image Credits: Bryce Durbin



# UAM Industry needs the manufacturing expertise and technology from the automotive industry to scale up eVTOL production.

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**Aerospace Industry** – Higher complexity and low economy of scale.



**UAM** - Production expertise and from Automotive + meeting aerospace requirements



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**Automotive Industry** – large economy of scale.

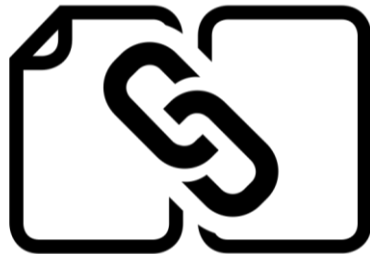


# Urban Air Mobility brings vehicles and designs matching with ROHACELL® offered benefits.

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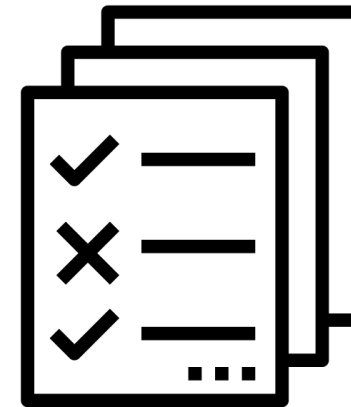
## New mobility market

Aligned with ROHACELL® target benefits – Light weight construction – Design Freedom



**Synergy** Aerospace and Automotive market combined

**Certified material for CS23 and CS25 regulation** – Aerospace certification already in place

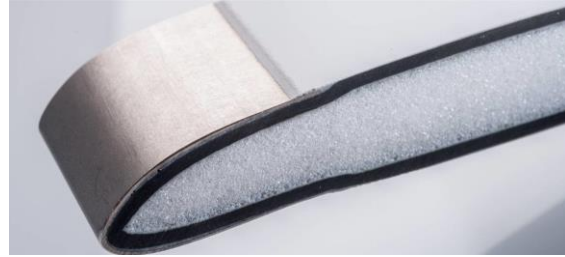




# Performance Foams Solutions from traditional aviation applications and qualified EN9100 available for UAM composite structures challenges.

## ROHACELL®

- Core material with superb heat resistance and creep compression strength.



## ROHACELL® SHAPES

- ROHACELL® service produce for net-shaped foam cores with high precision, to any geometry you require plus design consultation.



## ROHACELL® TRIPLE F

- Geometries that are complex and challenging to produce can now be foamed directly inside a mold, with the possibility to include inserts.



## ROHAFORM®

- Fully compliant Heat Release particle foam, In-Mold offering several complexity possibilities.

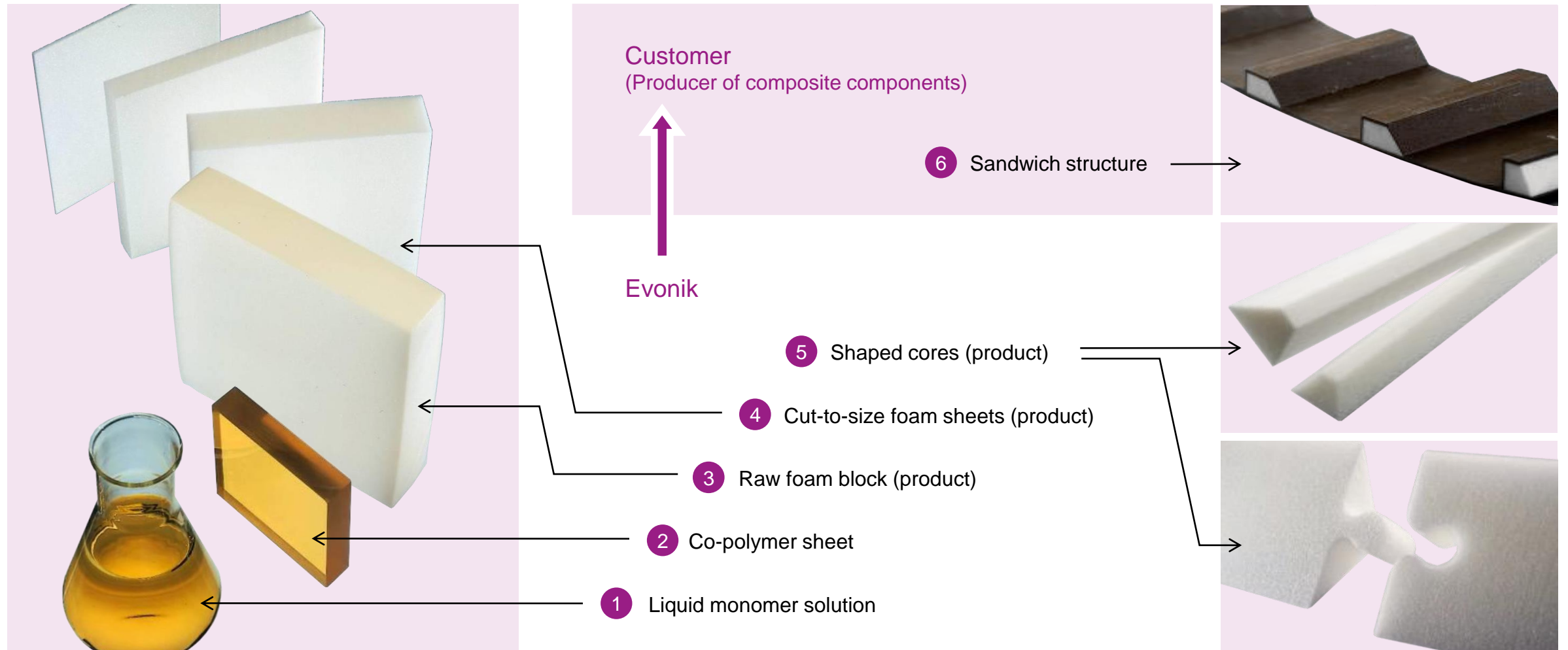


# ROHACELL®

Core material with superb heat resistance and creep compression strength.



# Performance Foams provides ROHACELL® sheets & shapes



# ROHACELL® Sandwich Technology

## Full Sandwich

The structural component is completely filled with the core material. The core geometry is adapted to the subsequent component shape.



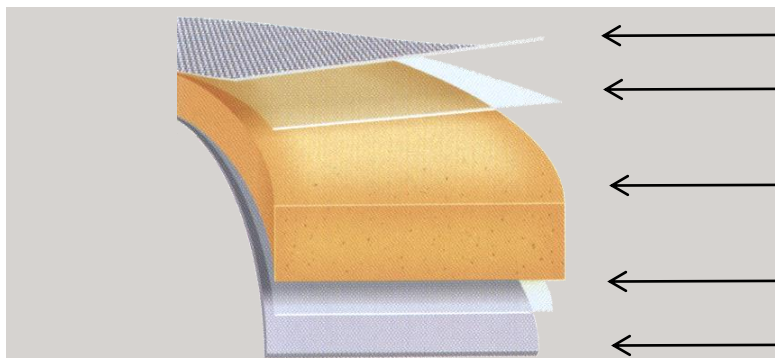
## Skin-Sandwich

The structural component is hollow. The skins are reinforced across each surface by a layer of core.



## Profile stiffened shell

Foam-filled stringers run along the component surface.



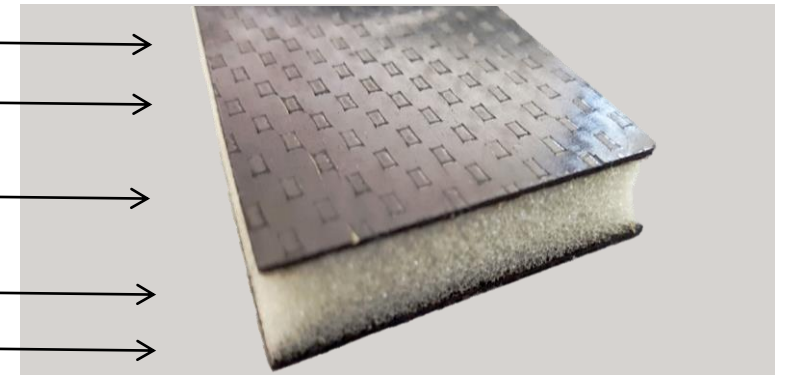
Carbon fibers

Resin

**ROHACELL® core**

Resin

Carbon fibers



# ROHACELL® sandwich design offers advantages along the value chain

## Design

- Integral design
- Fewer parts
- No potting
- Weight savings

## Processing

- One shot co-curing
- Up to 60% time reduction
- Potential process automation

## In-service performance

- No freeze / debonding damage
- Lower AC operational cost
- Stable weight (no water ingress)



- Cost reduction
- Stable process
- Automatization
- Robust in service



# ROHACELL® Products for the Aerospace Industry

ROHACELL® product	Processing conditions (up to)	Available densities (approx. kg/m <sup>3</sup> )	Special properties
A	up to 130 °C	31 / 51 / 71	Standard aircraft grade
HERO	up to 180 °C	51 / 71 / 110 / 150 / 200	Highest elongation at break
RIST-HT	up to 180 °C	51 / 71 / 110	Designed for resin infusion with very small cells
RIMA	up to 180 °C	51 / 71 / 110	Designed for resin infusion with the smallest cells
WF	up to 180 °C	51 / 71 / 110 / 200 / 300	Most qualified aircraft grade
XT	up to 190 °C	71 / 110	Can be used with BMI resins
EC	up to 180 °C	71 / 150	Electrically conductive, designed for UAVs and other stealth applications
HF	up to 130 °C	31 / 51 / 71	High frequency transparency, designed for radome applications

# ROHACELL SHAPES®

Service for net-shaped foam cores

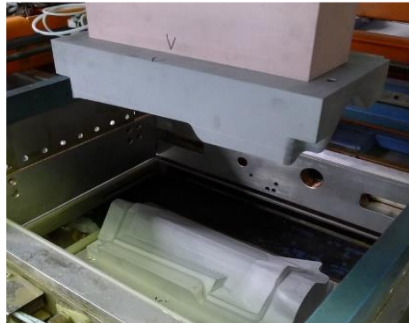


# ROHACELL® Shapes “CORE” competencies



## Engineering Service

- Economically design optimization
- puzzle solution



## Thermoforming

- Hot or Cold
- vacuum or press mould



## 5Ax CNC machining

- high precise shaping of your parts



## Quality Management

- DIN 9100
- FAI / ASB9102
- 3D inspection



## Smart packaging

- Sealed in specified bags MIL-131



## Tailormade Logistic

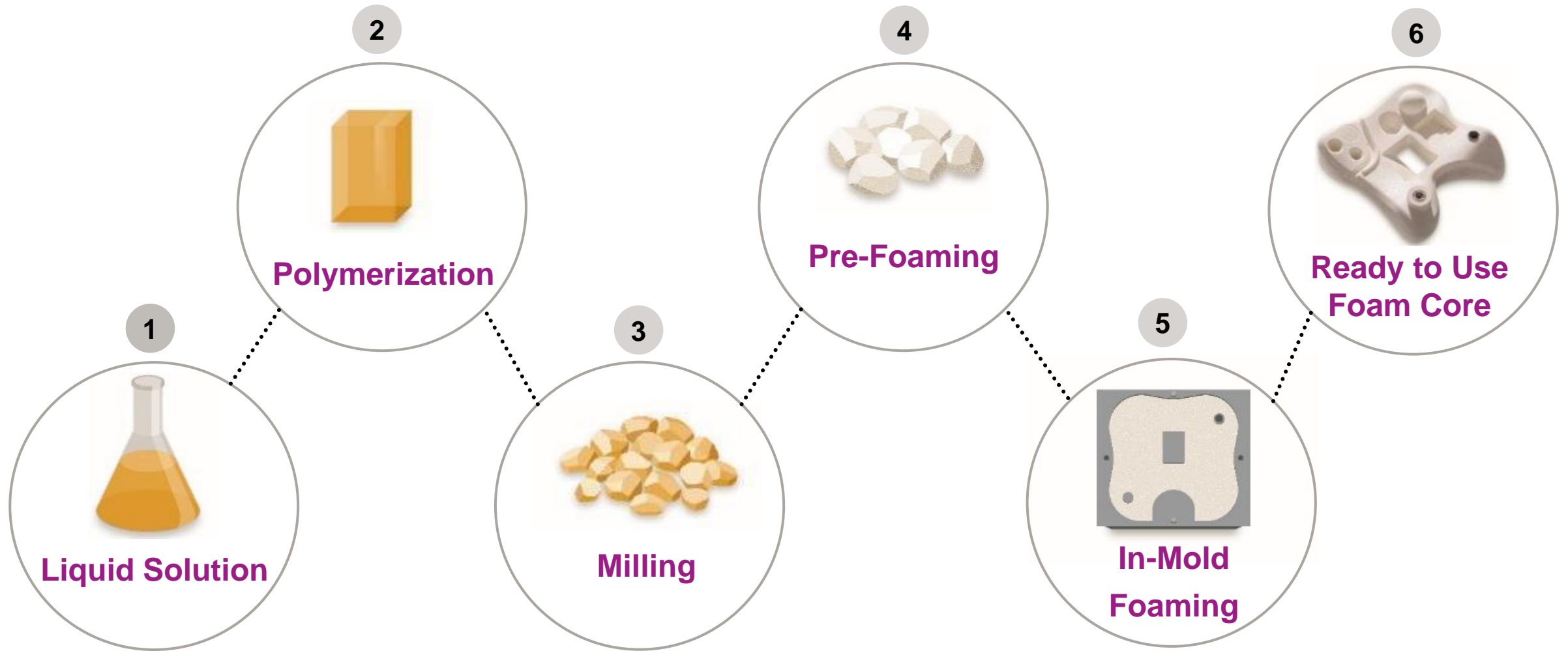
- customized packaging solution

# ROHACELL® TRIPLE F

In-Mold foam for high complex geometries



# ROHACELL® Triple F: Manufacturing Process





# Triple F offers solutions for different market challenges

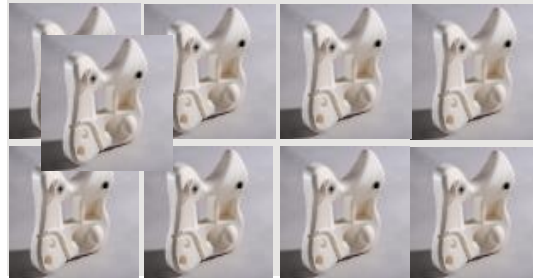
## Differential designs

**In Mold foam core offering maximum design freedom for complex parts**



## High volume applications

**High volume production with fast and reproducible process**



## Density requirements

**Density can be tailored according to customer needs**

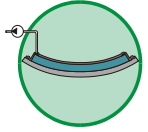


## Need for ready to use part

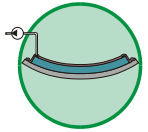
**Functional integration of inserts**



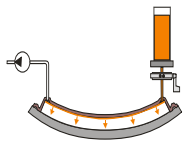
# Case Study about Materials & Process Technologies: Nose Landing Gear Door (NLGD)



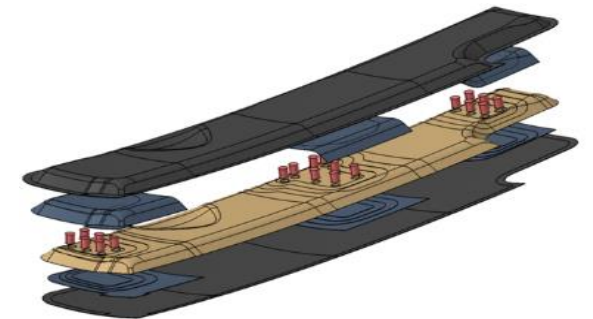
**Honeycomb / Prepreg:** Benchmark for the comparison is an NLG door similar to the A320 design and a process using Nomex Honeycomb ( $64 \text{ kg/m}^3 - 4,8 \text{ mm}$ ) and Prepreg (Fibredux 913C-926-40%).



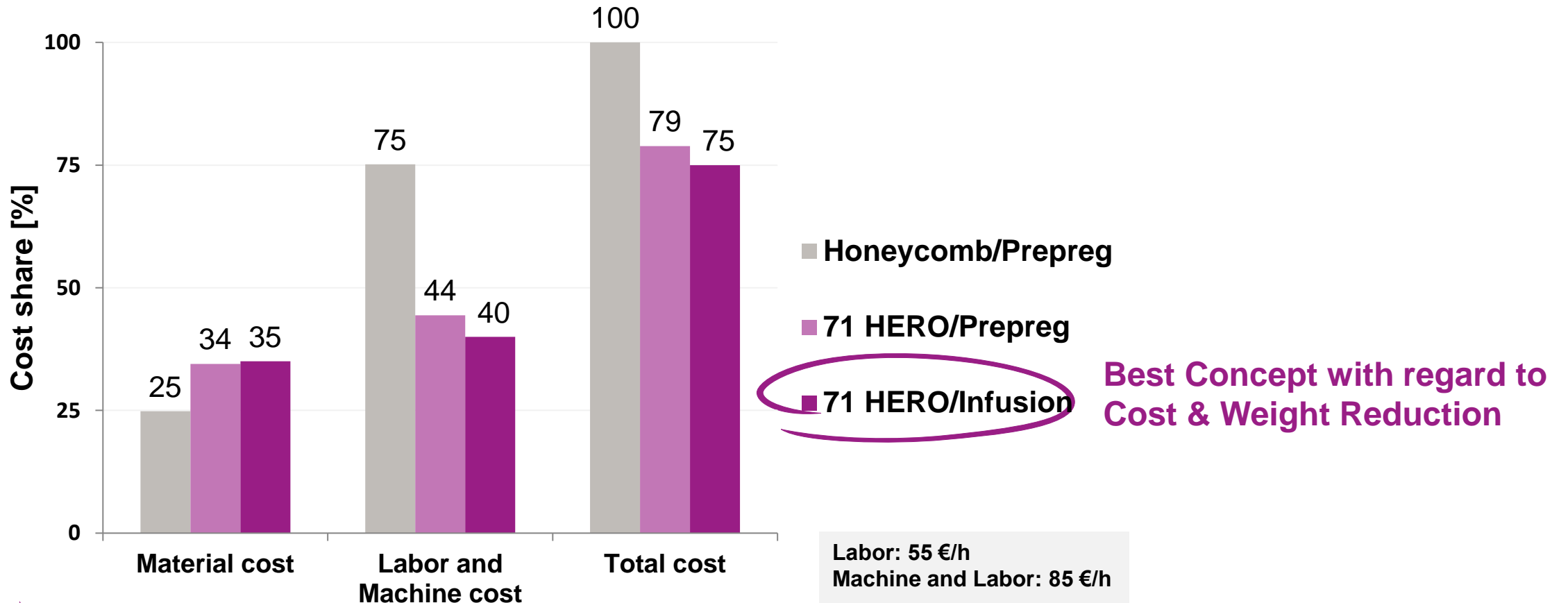
**Foam / Prepreg:** Additionally, we compare the 71 HERO foam with the Prepreg/Autoclave process in a situation where honeycomb is replaced by foam, but the process stays exactly the same ( $180 \text{ }^\circ\text{C} / 50 \text{ PSI}$ ).



**Foam / Dry Fabrics:** This foam sandwich part was originally constructed as a 71/200 WF core using infusion technique for Do728 aircraft. All qualification steps were completed. It was optimized for 71 HERO with dry fabrics to continue to use an infusion manufacturing technique.

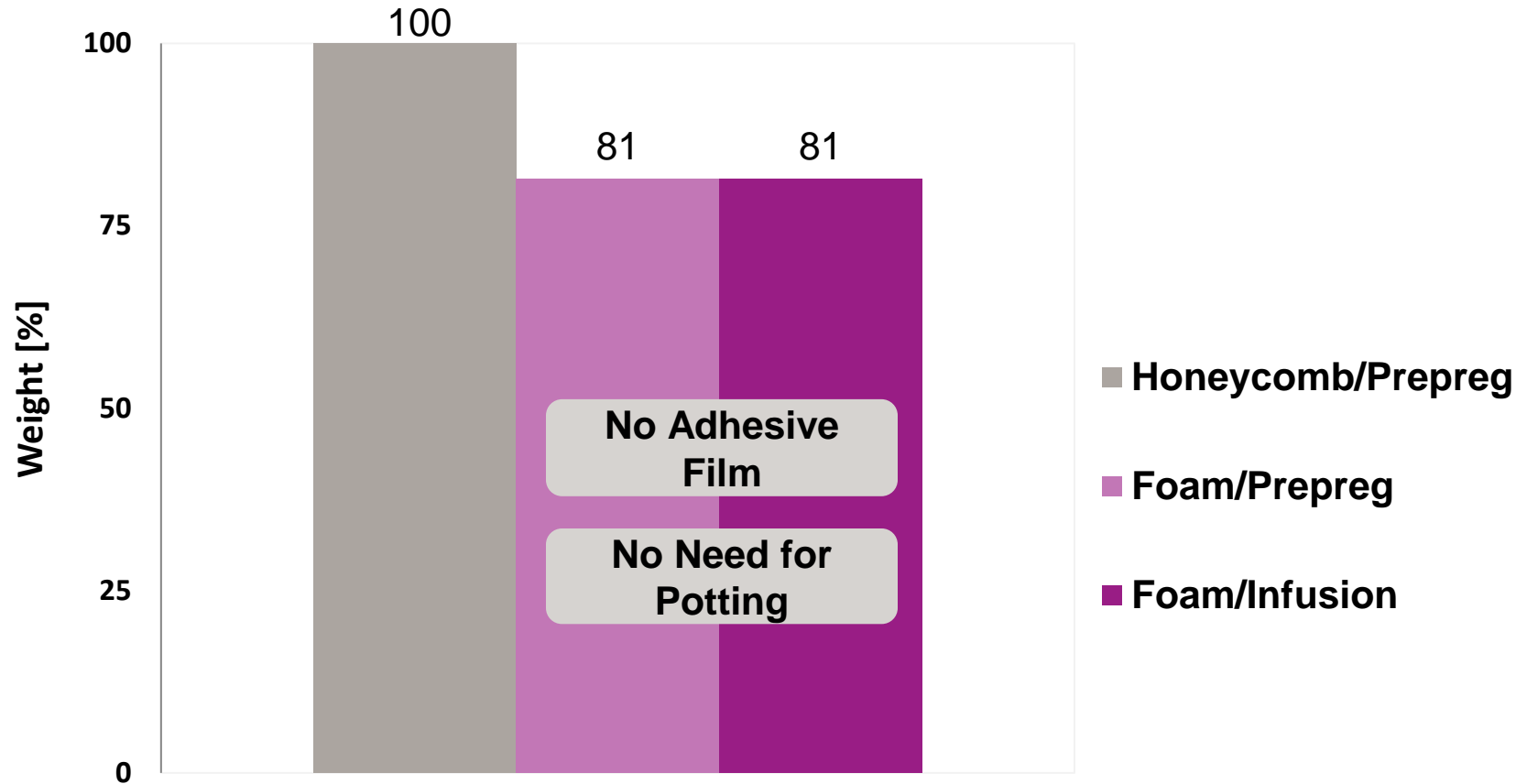


# Cost Analysis



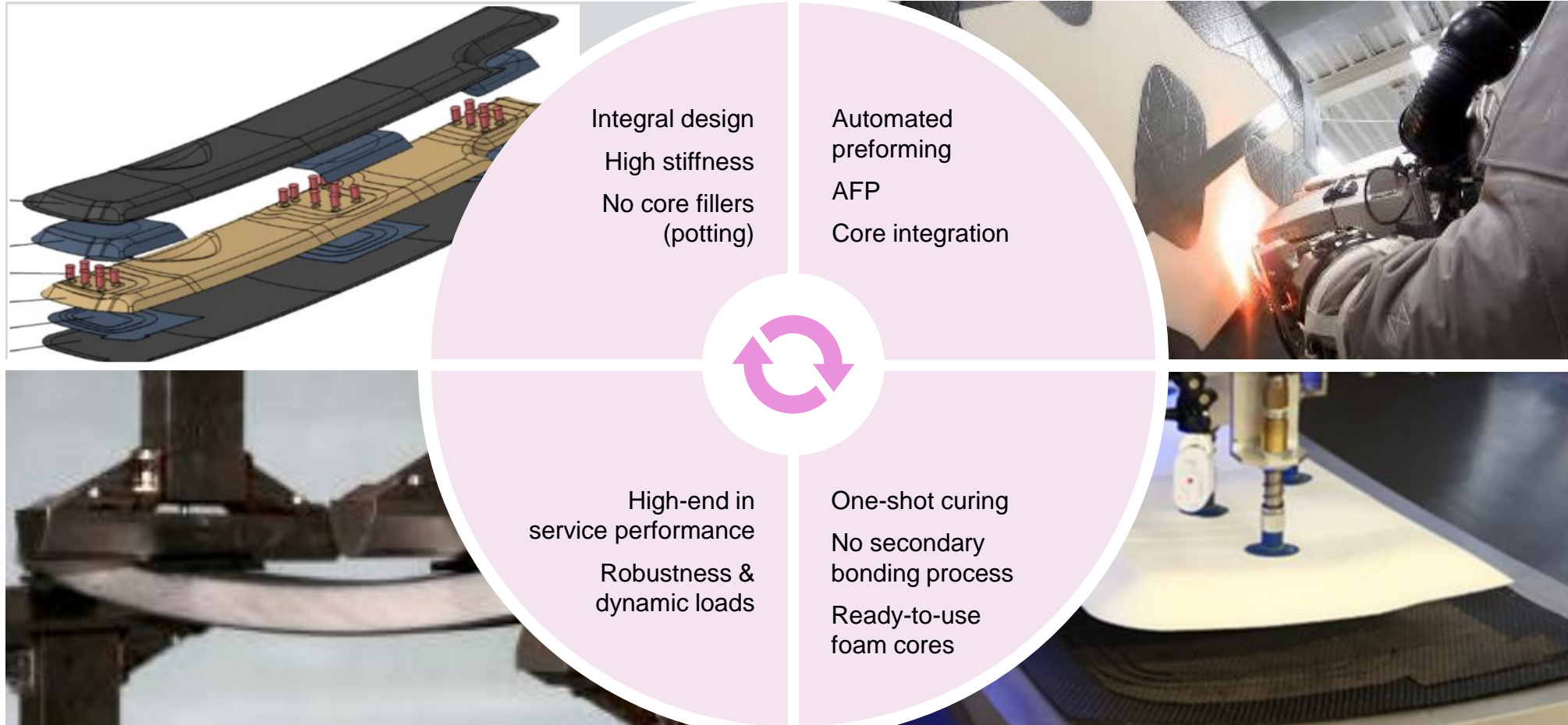
➔ Unit Production Costs Reduction of 21-25 % using PMI Foam and Prepreg/Autoclave or respectively Infusion Process in comparison to Honeycomb/Prepreg/Autoclave Process due to one shot curing technology as well as no need for core preparation and additional adhesive films.

# Structural Weight Analysis



➔ NLG Door Part Weight Reduction of 19 % using ROHACELL® HERO in comparison to Honeycomb

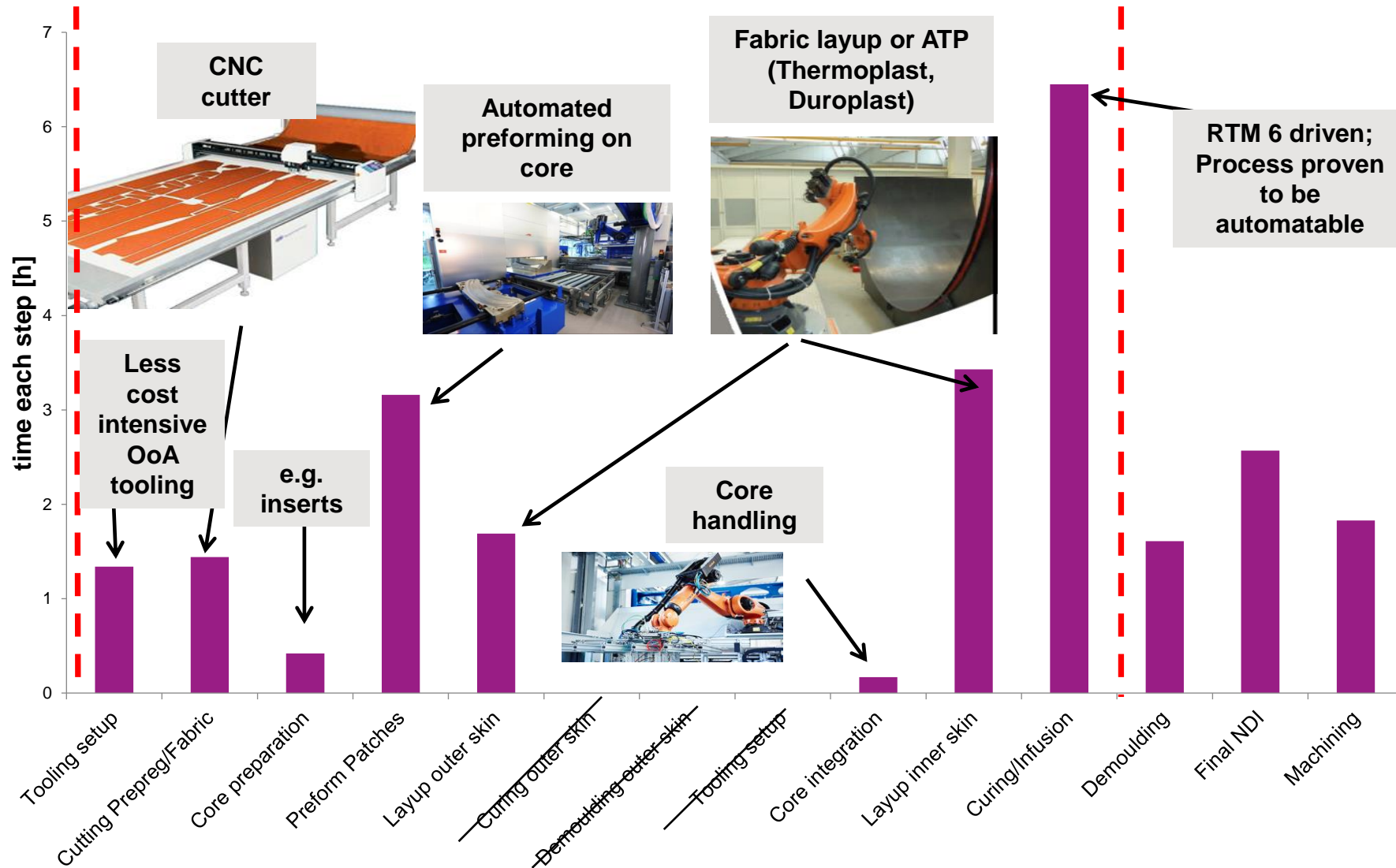
# Cost- and capacity-driven part concept





# Scope of the Automation Case Study

Time by process step (NLG door) and automatization potential



## Project Partners:

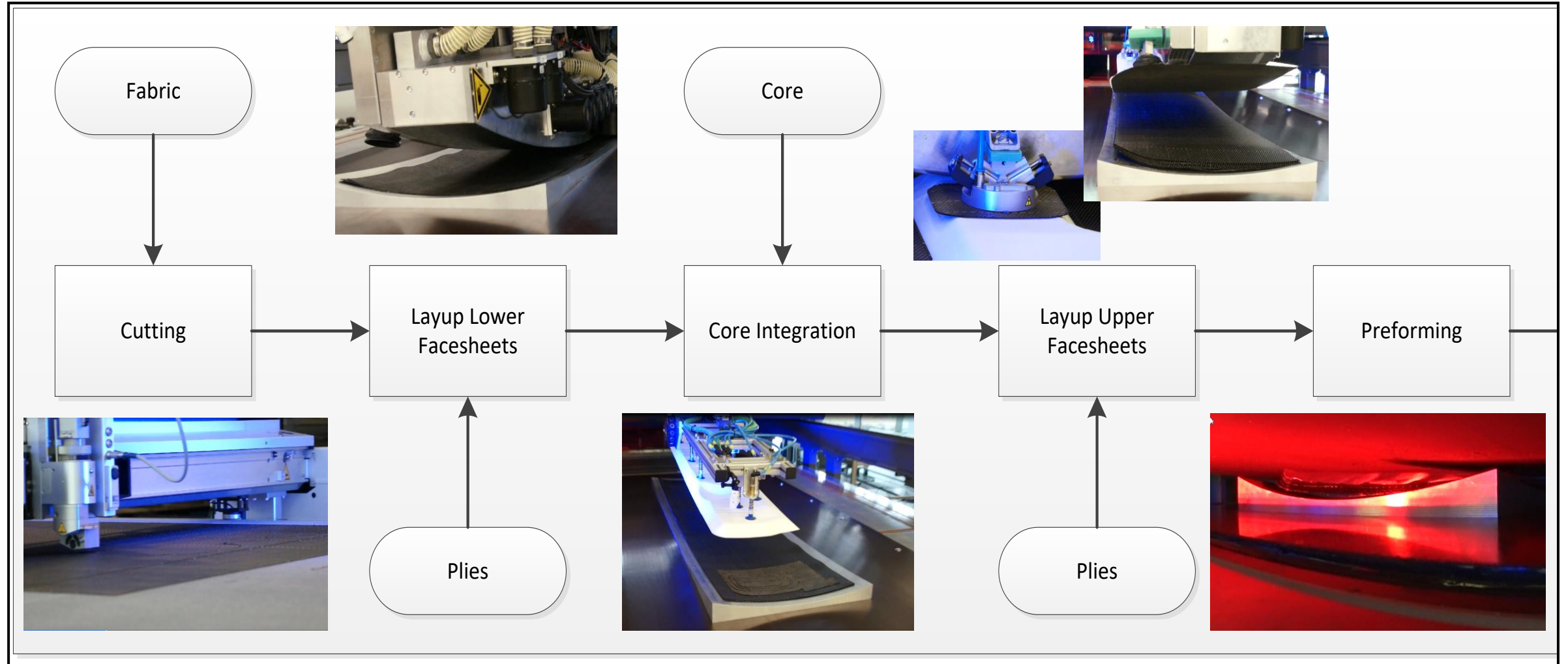


Project scope

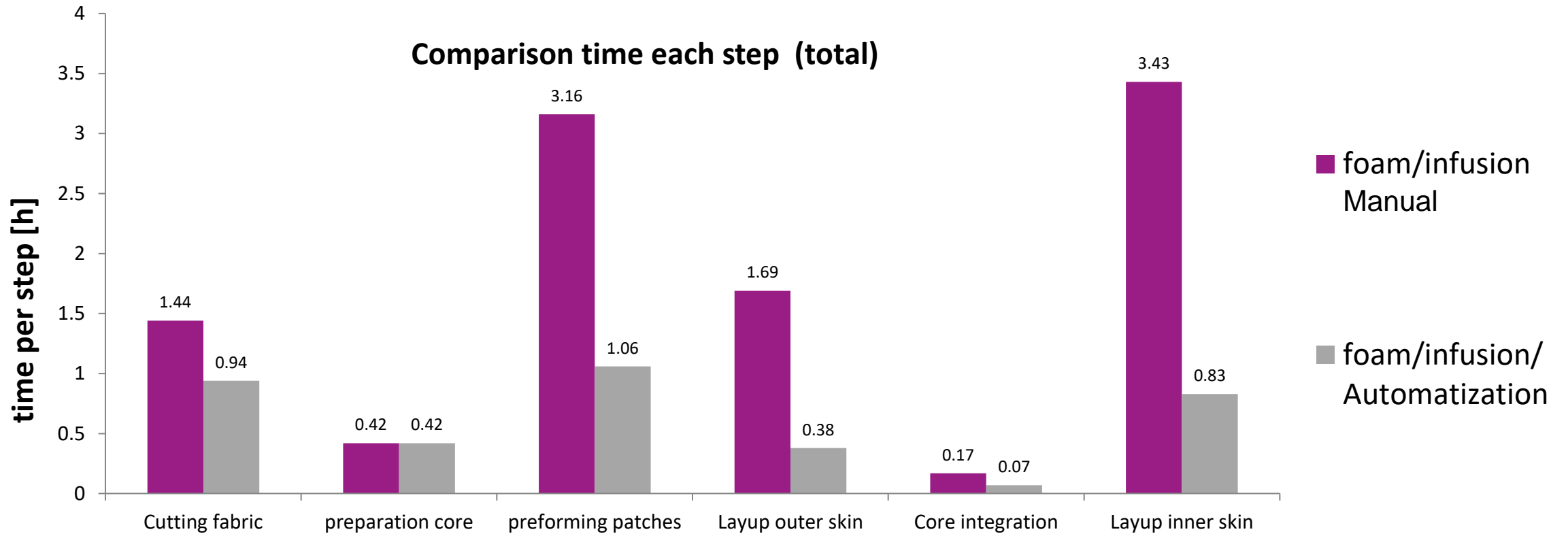
■ Foam/Infusion (1 shot curing)

All relevant Production Steps within the Project Scope are automated

# Sandwich-Preforming: Cutting, Lay-Up and Compaction



# Time savings due to automatization

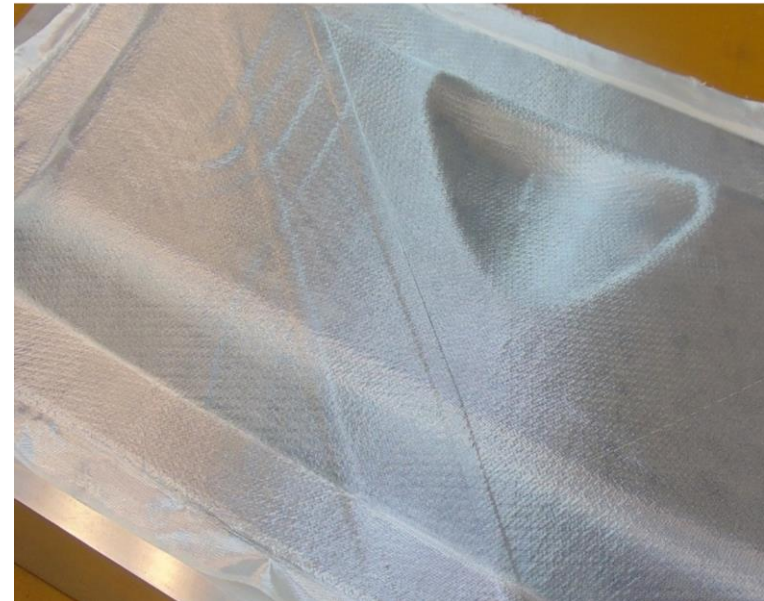
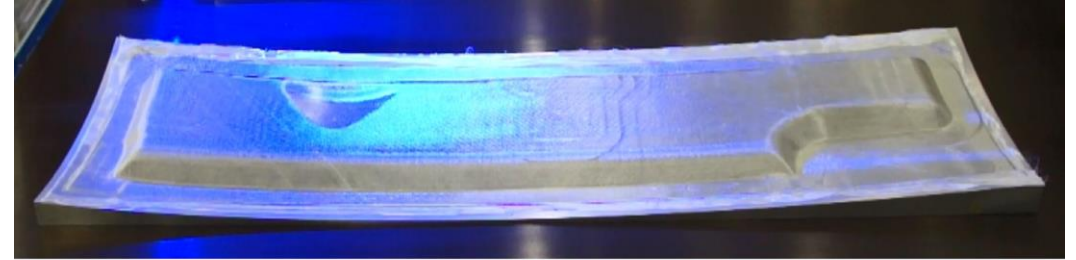


~ 65% less tool utilization time

Estimated 35% cost reduction

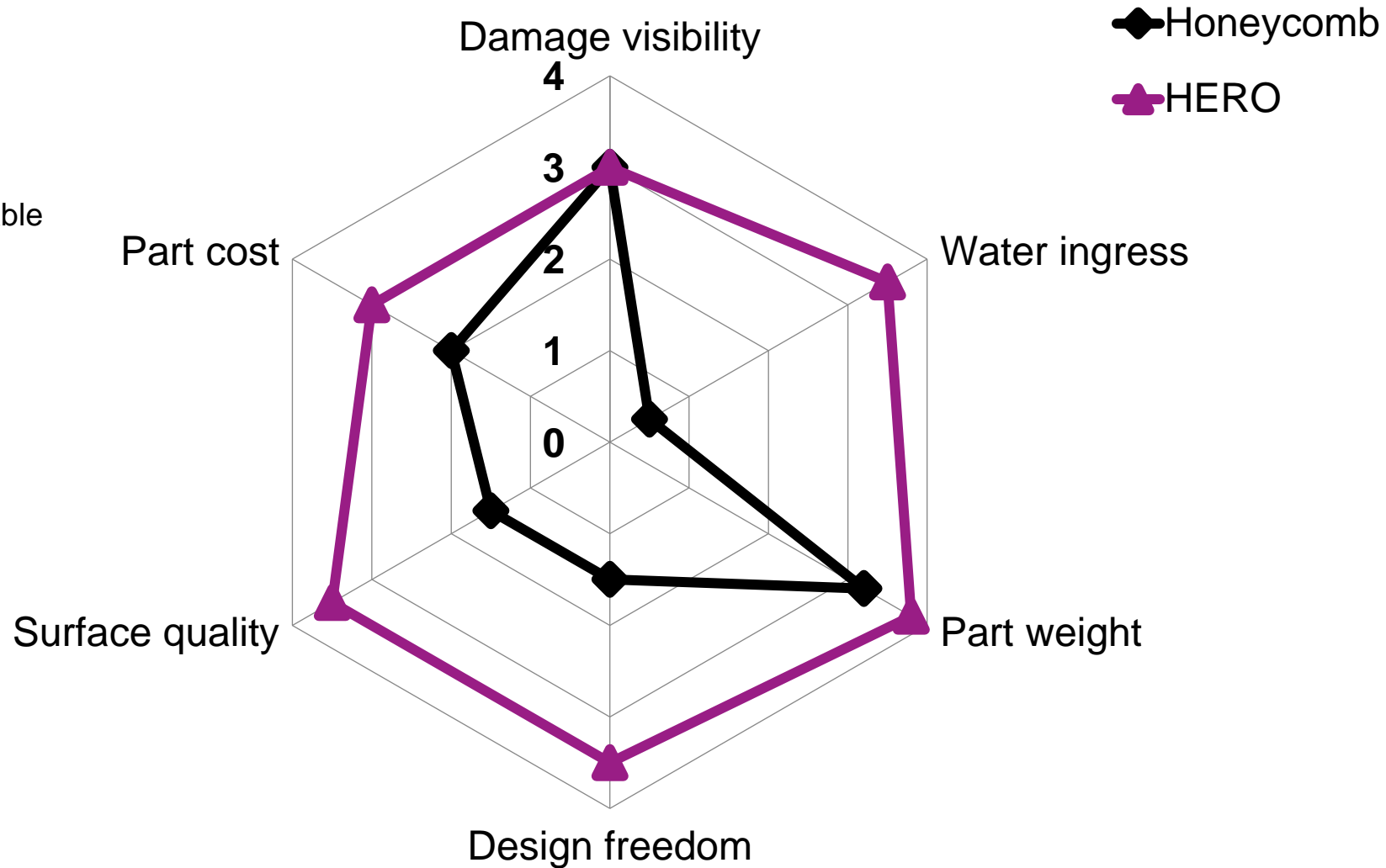
# Advantages of PMI Foam as Core Material for automated Composite Sandwich Fabrication

- Rigidity of the Foam leads to a self stable Core Part
- **Accurate and stable Geometry allows Handling by Robot**
- Easy Handling with state-of-the-art Vacuum Grabbers
- Precise Pick & Place Operation
- High Compressive Strength and Temperature Resistance of PMI Foam makes Preforming directly on Core possible
- No Fiber Undulation after Preforming
- Preform Compaction on Core leads to high Quality Sandwich Composite Parts and good Consolidation of FRP Skins
- Setup is proven to meet Aerospace Industry Quality Standard
- **Unit Production Costs Reduction of up to 30 % is expected using automated Process Technology**



# ROHACELL® HERO outperforms Honeycomb.

- 4 - Superior
- 3 - Excellent
- 2 - Very good
- 1 - Good
- 0 - Unacceptable





# ROHAFORM®

Fully compliant Heat Release particle foam



# ROHAFORM®

## Elevating thermoplastic particle foam processing to a new, efficient level

Micro-Granule preparation



Particle pre-foaming



Steam chest molding



# ROHAFORM® in-mold foamed cores

## Ideal for high volume production applications

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- Tailorable density & tight density range
- Core-to-core consistency and reliability
- Compatible with state-of-the-art and innovative resins
- Meets strict FST and Heat Release requirements
- Outstanding thermal-mechanical properties
- Integration of inserts and other functionality
- 3D foaming of basic or complex geometries
- Contributes to your sustainability goal





# Rigid PMI Foam Cores ROHACELL® is the material choice for Urban Air Mobility



- Urban Air Mobility market expects rapid growth and will require materials with automation capacity and mass production scale, with aerospace qualification.
- ROHACELL® is an Aerospace certified material (Qualified against MIL-PRF-46194, WL 51461 and further Customer Specifications) also used in the automotive industry and high fit for automation.
- ROHACELL® offers efficient automated Manufacturing Process resulting in reduced Preform Processing Time of approx. 65 % and total Unit Production Costs of approx. 25-30 %.
- ROHACELL® offers up to 20% of structural weight savings of the final sandwich composite part.
- Evonik extends its portfolio going beyond ROHACELL® and offering In-mold foam and new FST properties foam ROHAFORM®.
- ROHACELL® organization is certified against EN9100.

# ROHACELL®

## Sales and technical support

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