



AUTOMATION

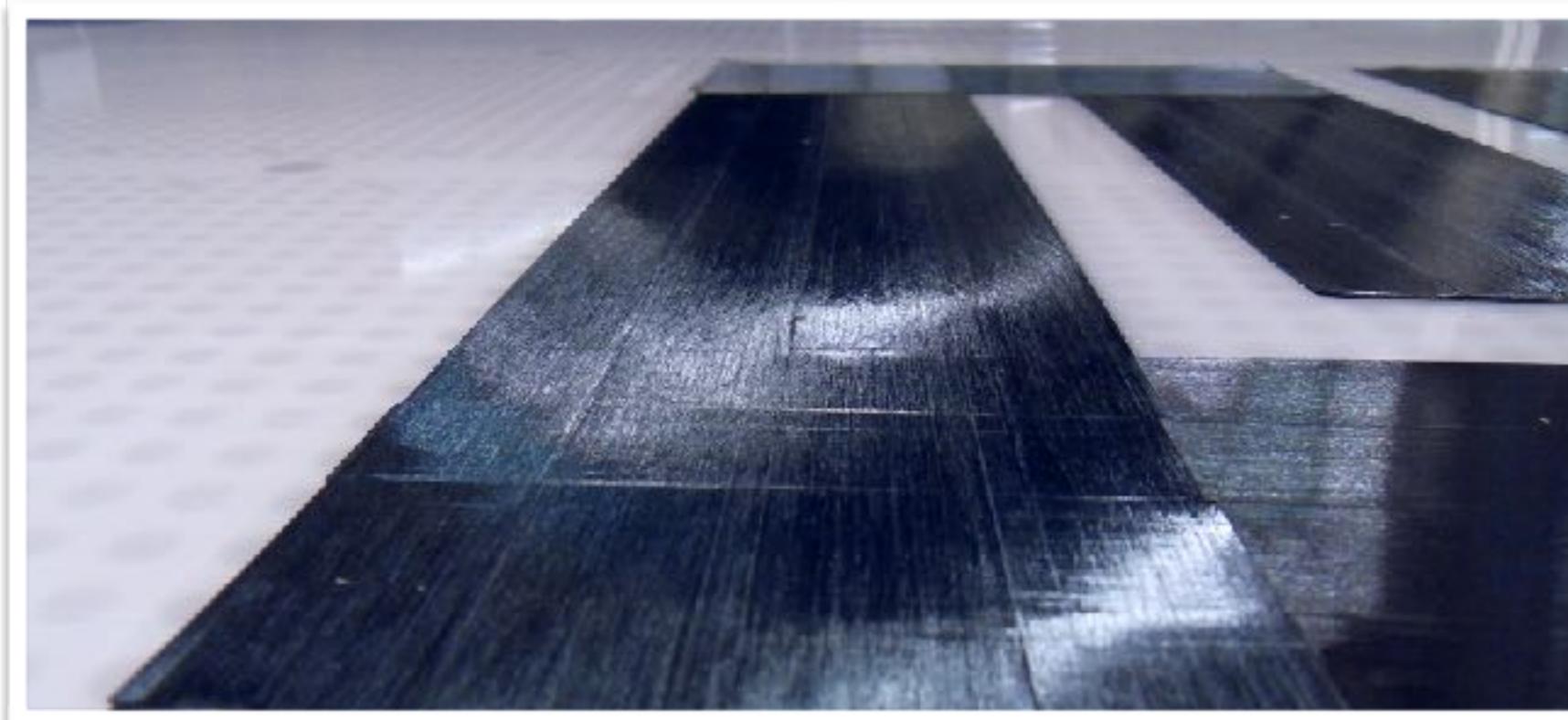
STEEG & HOFFMEYER

Automation Steeg und Hoffmeyer GmbH
Mainzer Landstrasse 155
55257 Budenheim

Facts and Figures F²-Composite® and F²-Compositor® Short Version

Dr.-Ing. Markus Steeg

What is thermoplastic tape placement?

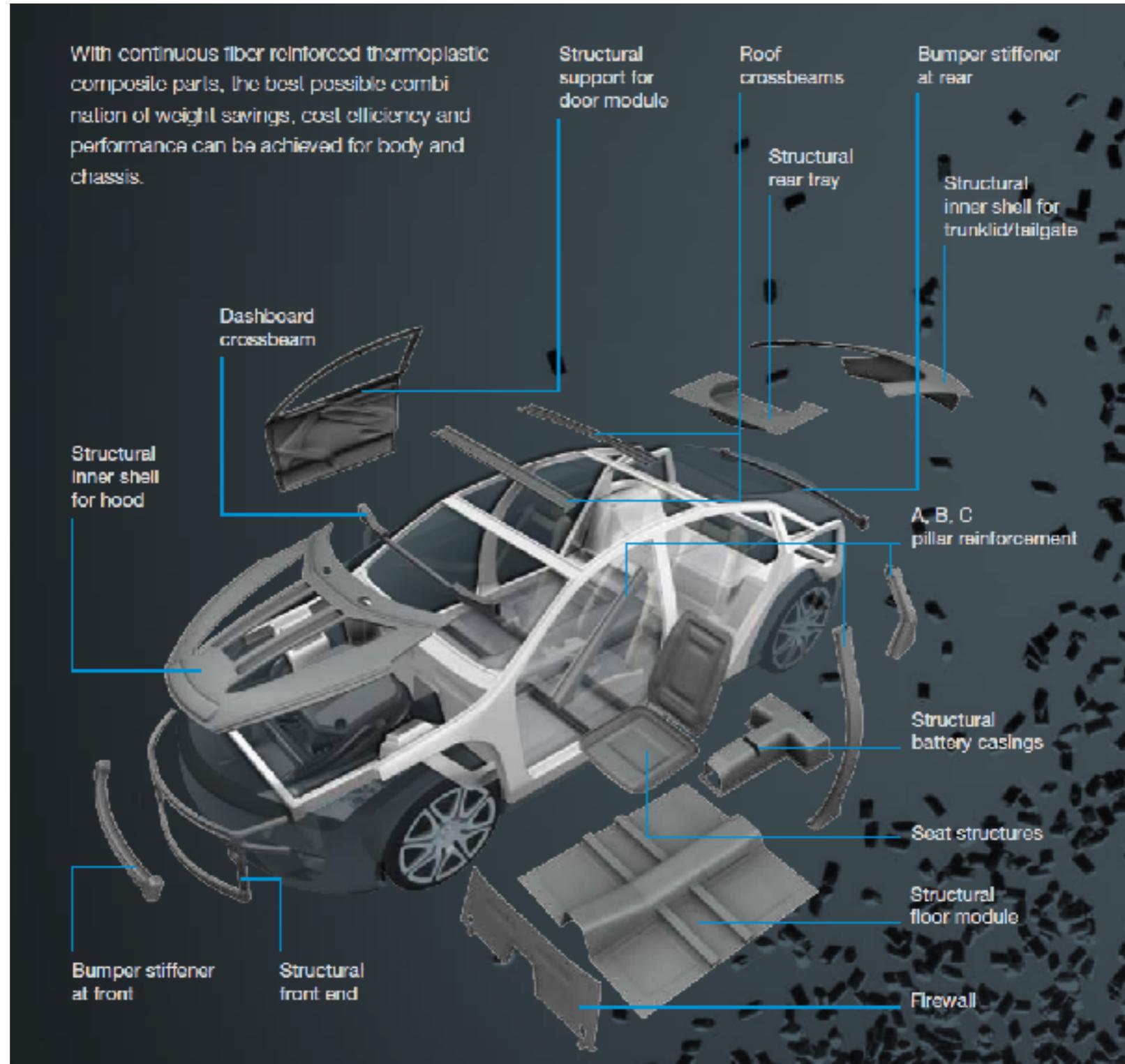


Tape placement is an automated, orientation variable, and position variable lay up process for unidirectional fiber reinforced tapes on molds.

(Beresheim)

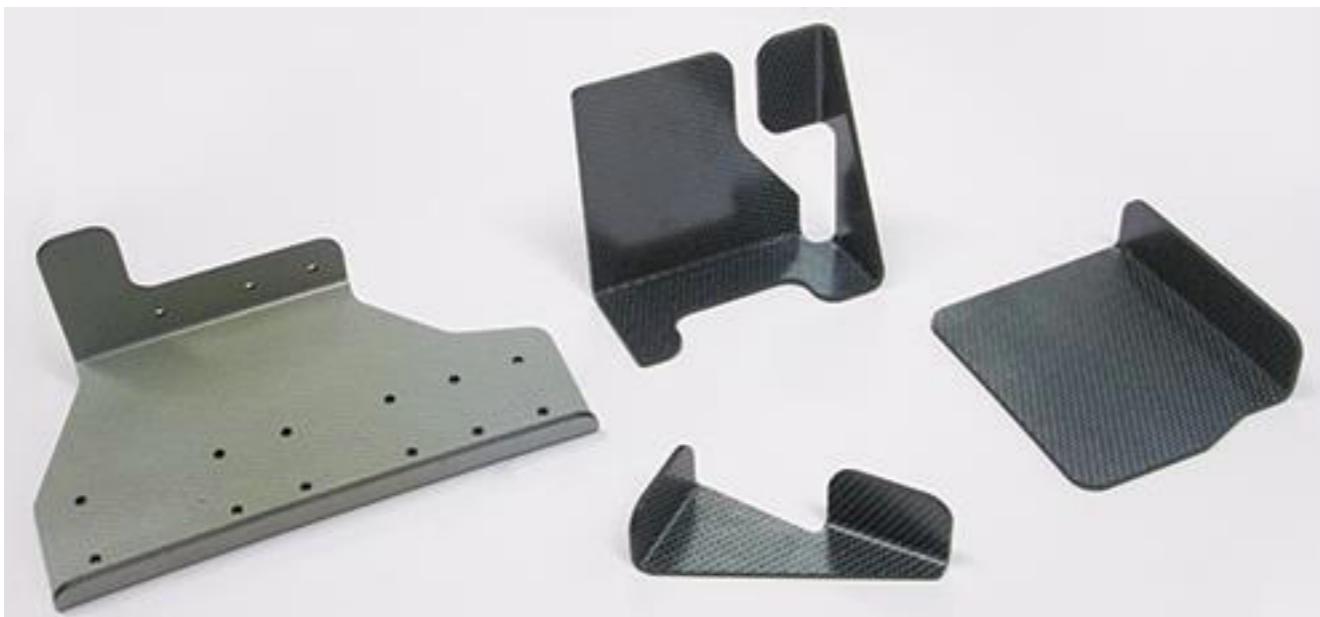
Tapes are welded on top of each other with a heating source. The preform is solid and can be transported and stored automatically.

Where to use thermoplastic tape placement? Automotive scenario



<http://www.automotive.bASF.com/wp-content/uploads/2014/02/ultracom.png>

Where to use thermoplastic tape placement? Aviation scenario

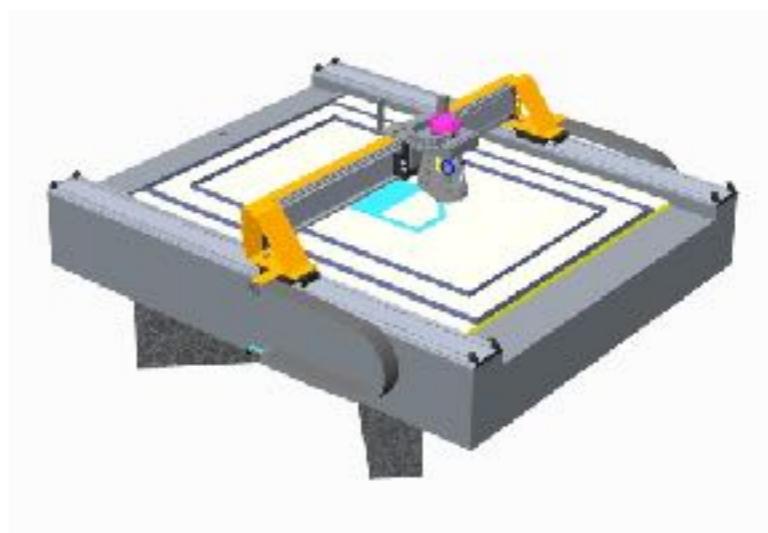


<http://www.compositesworld.com/articles/thermoplastic-composites-clip-time-labor-on-small-but-crucial-parts>

What is F²-Composite®?

What is F²-Compositor®?

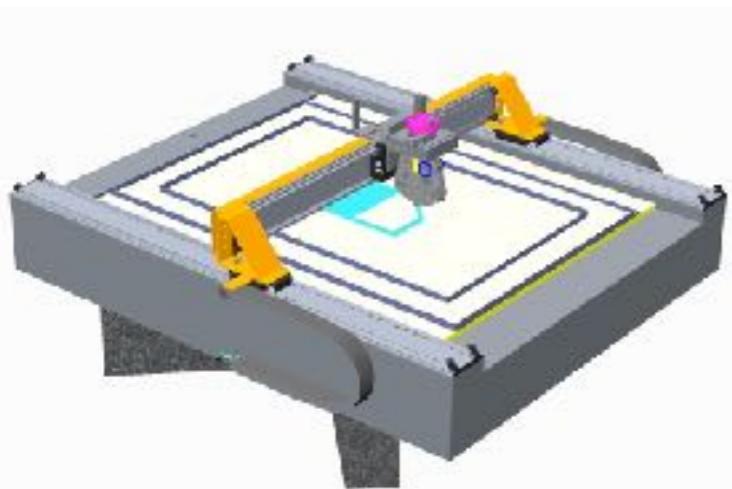
- F²-Composite®
 - fiber placement technology
 - thin film melting and joining
 - drive technology
 - CNC techniques
 - synchronization
 - net-shape contour simulation
 - waste simulation
- F²-Compositor®
 - miniaturization and parallelization
 - highly customizable machine for fiber placement
 - design follows customers' needs
 - degree of automation follows customers' needs
 - output follows customers' needs





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F²-Compositor® design freedom



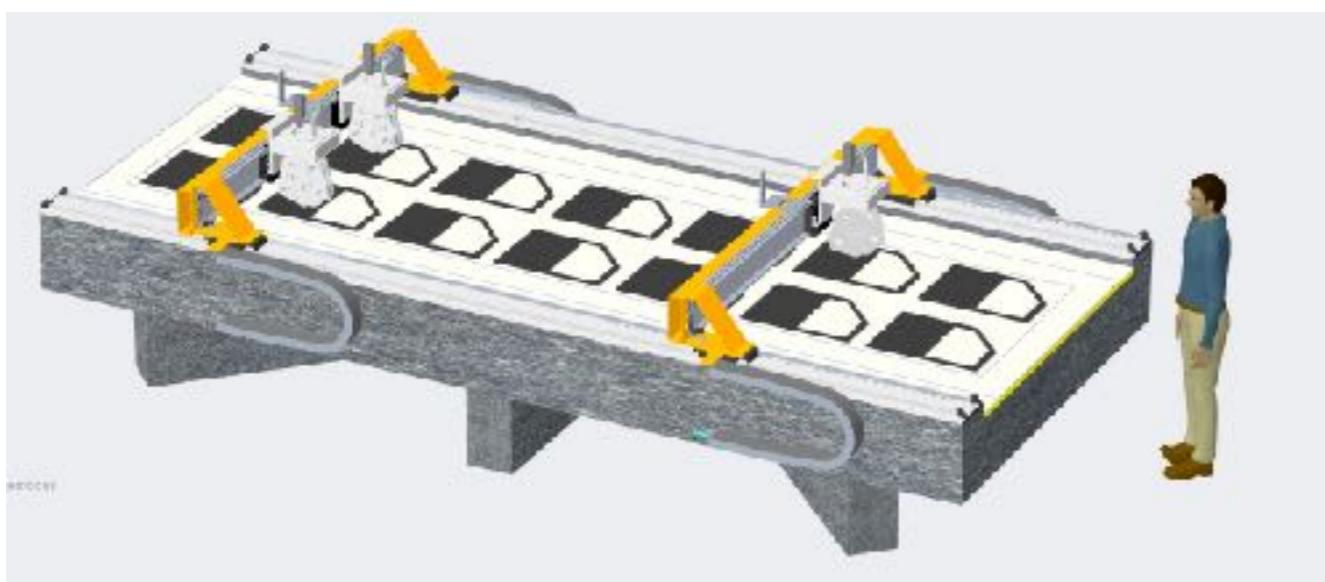
tape placement, flexible tape width
F²-Compositor
dimension 4 m x 2.65m*



tape placement, tape winding and both
together, material supply on board
F²-Compositor LabCube
dimension 1.9 m x 1.4 m



tape placement, fixed tape width, UD
material supply on board
F^{2.5}-Compositor
dimension 5.2 m x 0.9 m

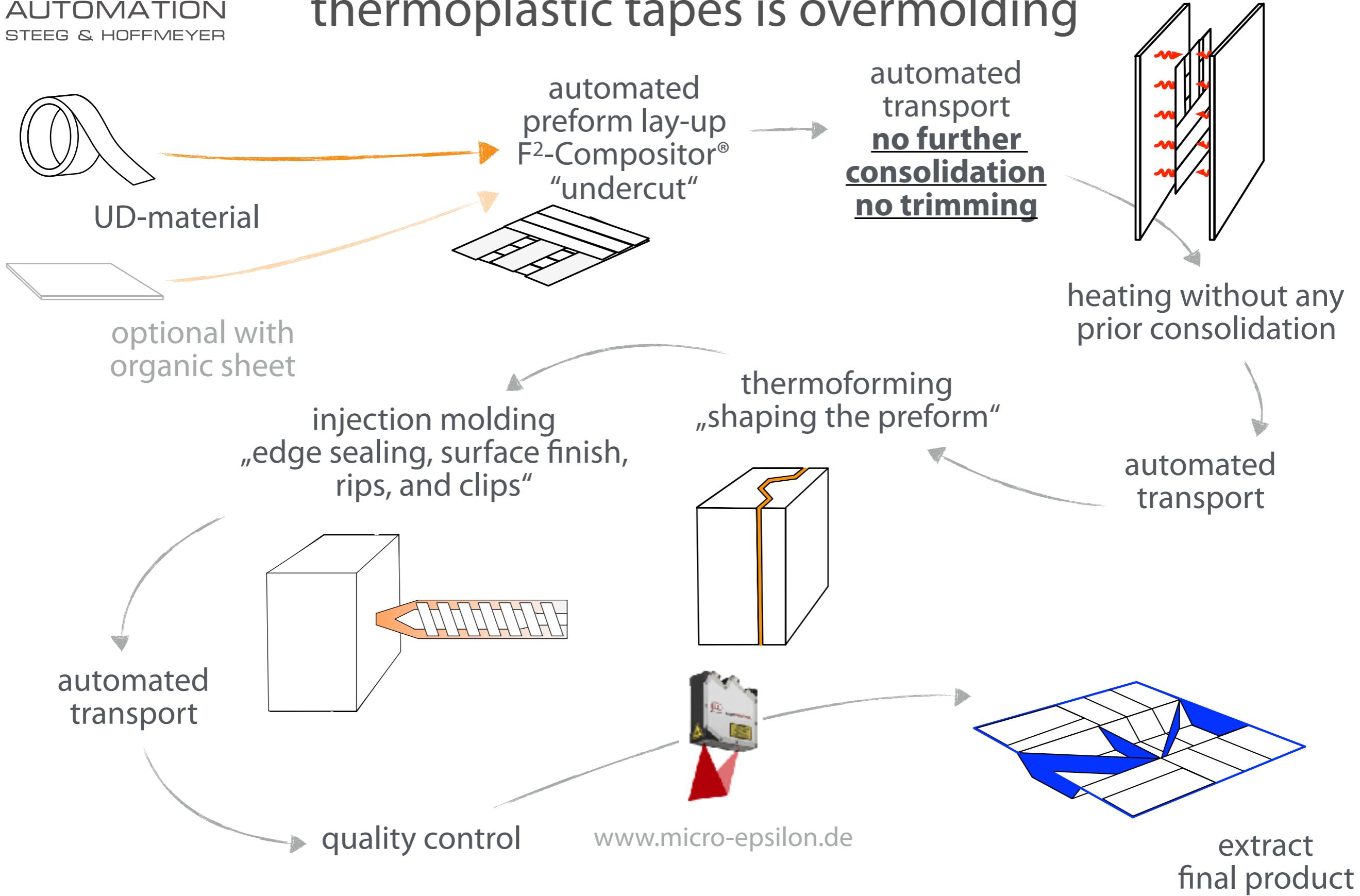


tape placement, flexible tape width
F²-Compositor dimension 4 m x 2.65m*



tape placement, fixed tape width,
material supply on board
F²-Compositor LabCube
dimension 0.9 m x 0.8 m

F²-Composite[®], one process scenario for thermoplastic tapes is overmolding





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Facts F²-Compositor®

Investment range	85 k€ up to 1.5 m€ EXW, with documentation, without qualification effort*	less than competition (factor of 2-15)
Tape laying rate	5 kg/h up to 725 kg/h or more	difficult to compare
Tape width per application unit	5 mm up to 75 mm	unknown
Necessary power to produce a consolidated preform: Heating source + movement	1.5 kW/h up to 25 kW/h	less than competition (factor of 50-100)
Exposure time polymer above the melting point, to manufacture a consolidated preform for further IR-processing	0.025 s	less than competition (factor of 40.000)
Placement speed with precision	1-3 m/s	faster than competition (factor of 2-4)
Acceleration, deceleration with precision	20-50 m/s ²	faster than robots (factor of 10-25)
Workshop area to install a F ² -Compositor® with all infrastructure	10 m ² up to 38 m ²	less than competition (factor of 2-20)
Tested polymers with reinforcement	PP, PE, PA, PA derivates, PPA, PPS, PEEK, PEKK, "prepreg", ...	same as competition
Tested polymers without reinforcement	PP, PE, et. al.	unknown
Tested carrier substrate	None, polymer, polymer film, FRPC, sandwich, foam, steel, aluminium, wood, concrete	unknown
Waste	Waste intended to be none with miniaturization and design options of the F ² -Compositor®	difficult to compare
Design options	Coupling several small F ² -Compositors® to an assembly line, possible and reasonable to have no waste and a high laying rate Automatic spool change upon request F ² -Compositor® to F ² "out of plane"-Compositor	unknown

What is the difference?

- We do not buy robots, we built them!
- We have our own customized drives!
- We have a single control unit, covering all processes!
- We have a much cheaper heating source!
- We do not use a laser, causing secondary costs for safety equipment and safety education!
- We generate the polymer melt only in the joining zone, so we have an energy efficient heating process!
- We use an energy recovery system to store and release the motion energy, especially on short tracks!
- We do not have a huge overhead!

Summary short version

- Old technology, reloaded with less mass, new drive technology and enormous control power
- The F²-Compositor® should be faster and cheaper than most other technologies available
- You will see an efficiency increase with customized machine design

Thank you for your attention



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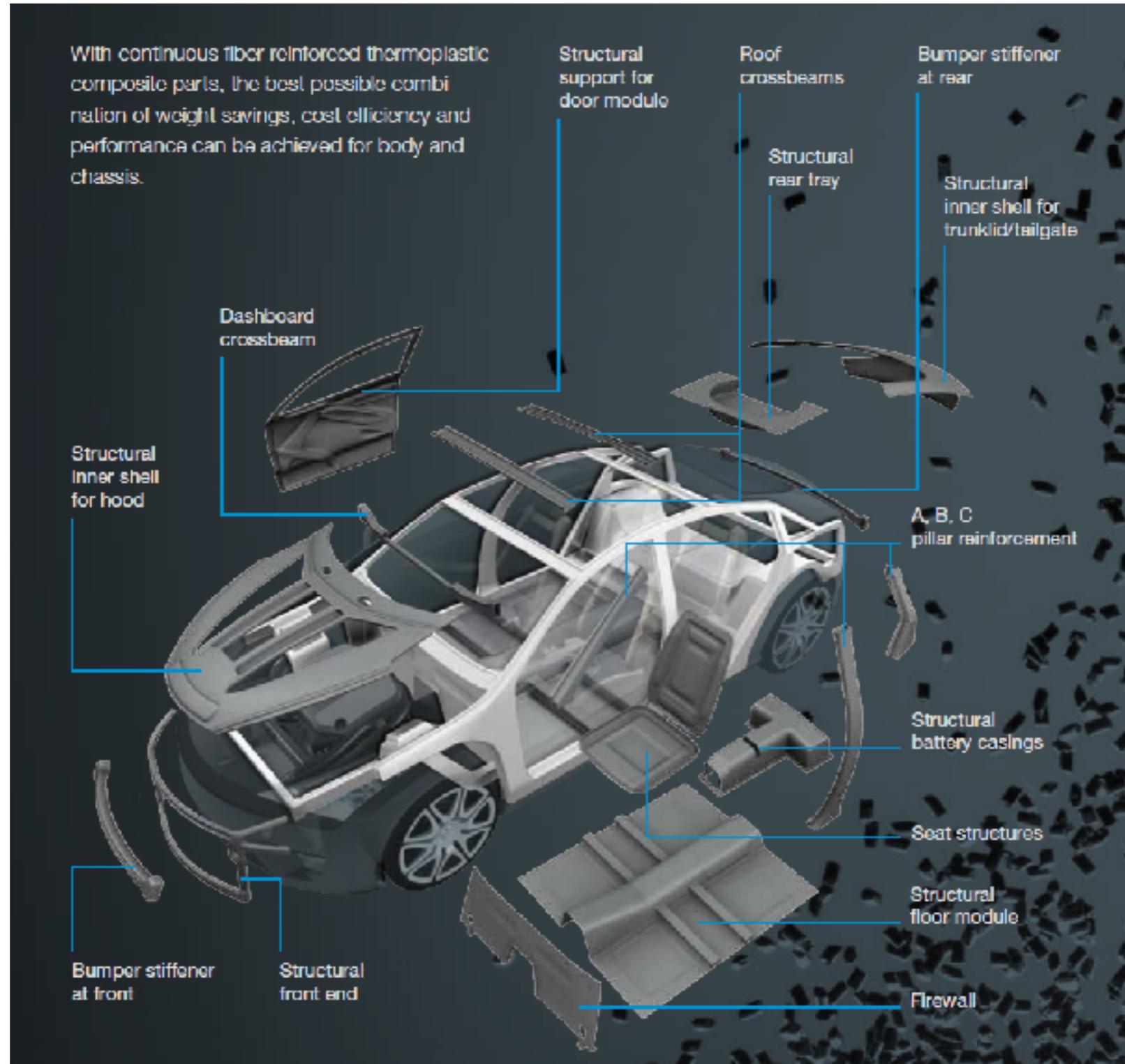
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Facts and Figures F²-Composite® and F²-Compositor® Long Version

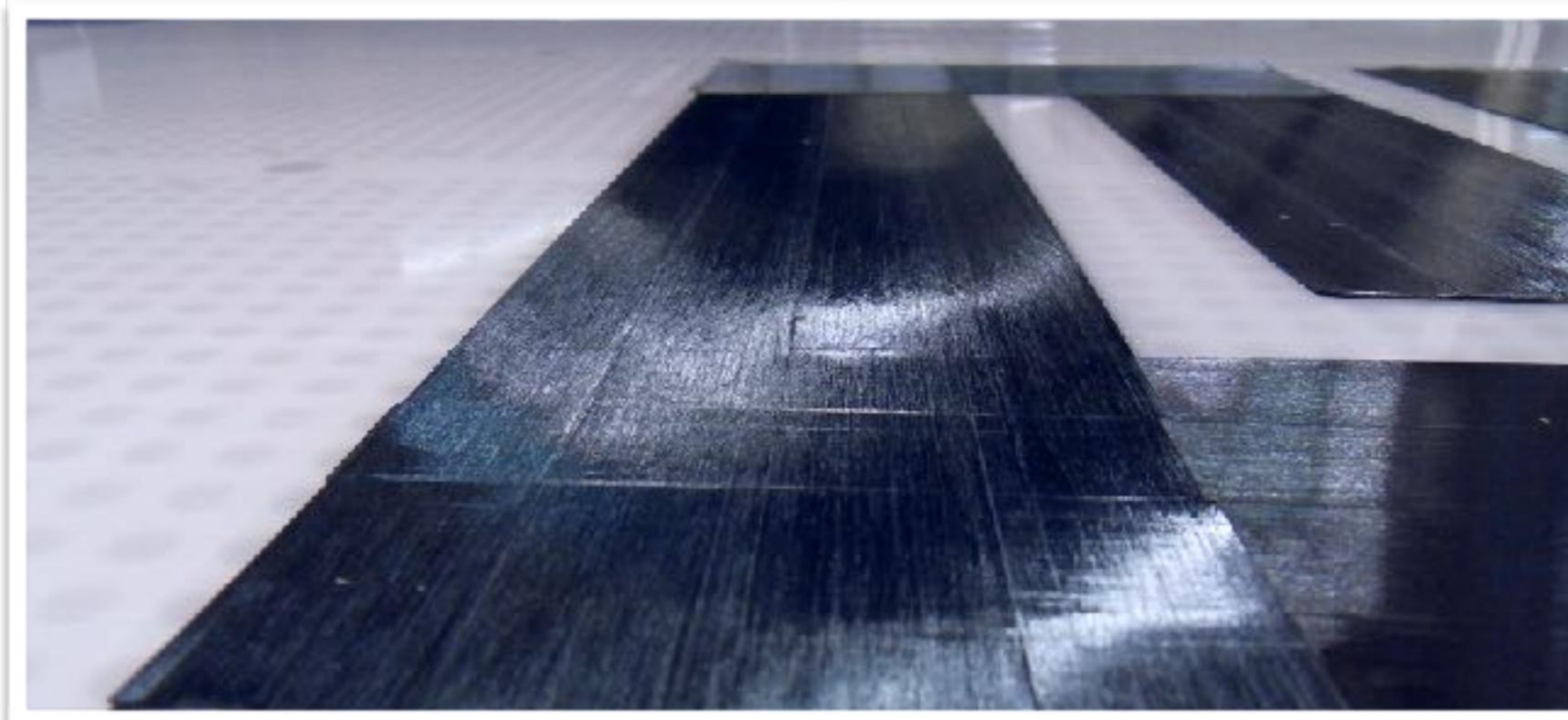
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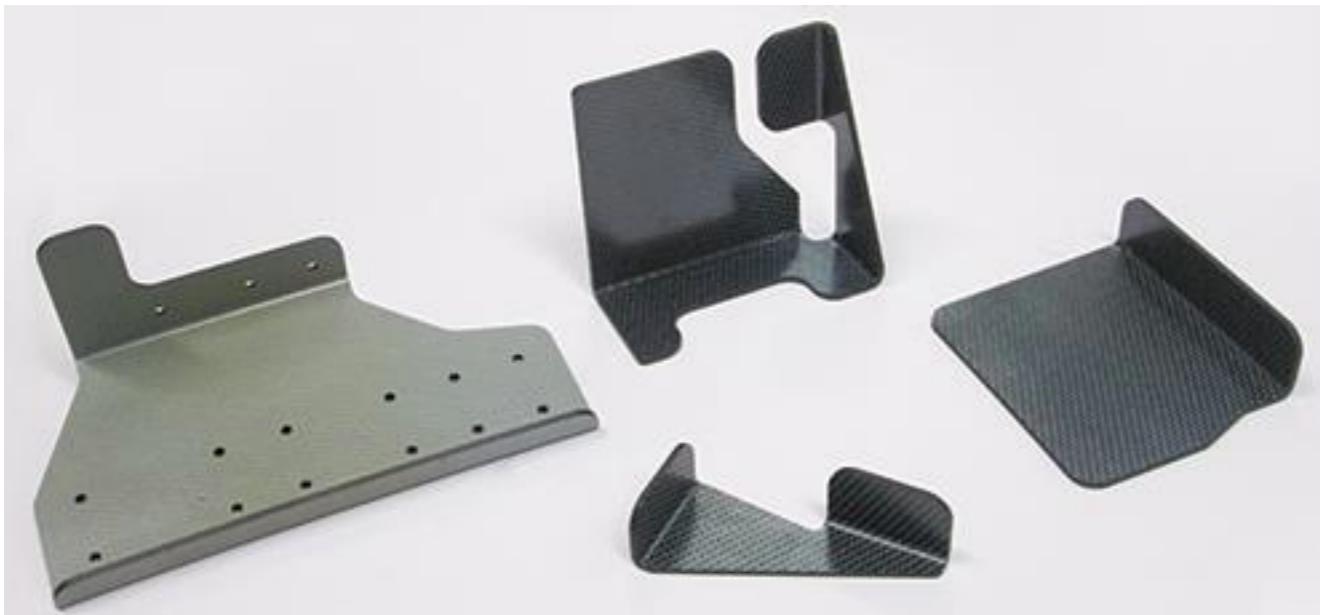


Tape placement is an automated, orientation variable, and position variable lay up process for unidirectional fiber reinforced tapes on molds.

(Beresheim)

Tapes are welded on top of each other with a heating source. The preform is solid and can be transported and stored automatically.

Where to use tape placement? Aviation scenario

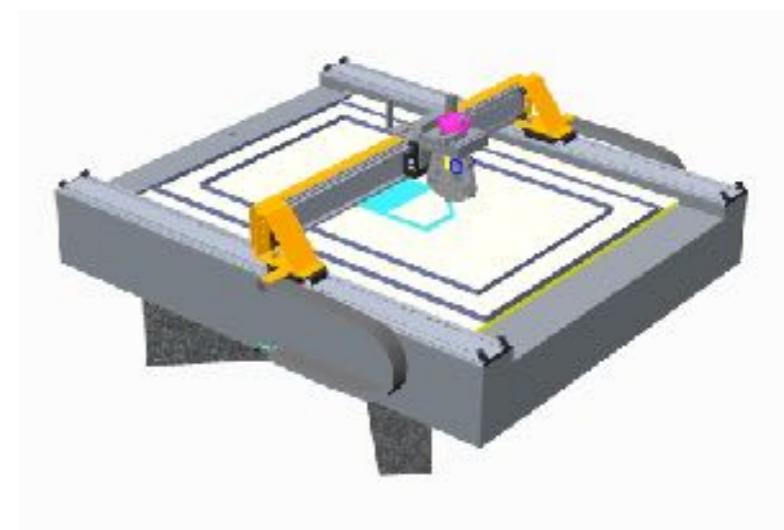


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What is F²-Composite®?

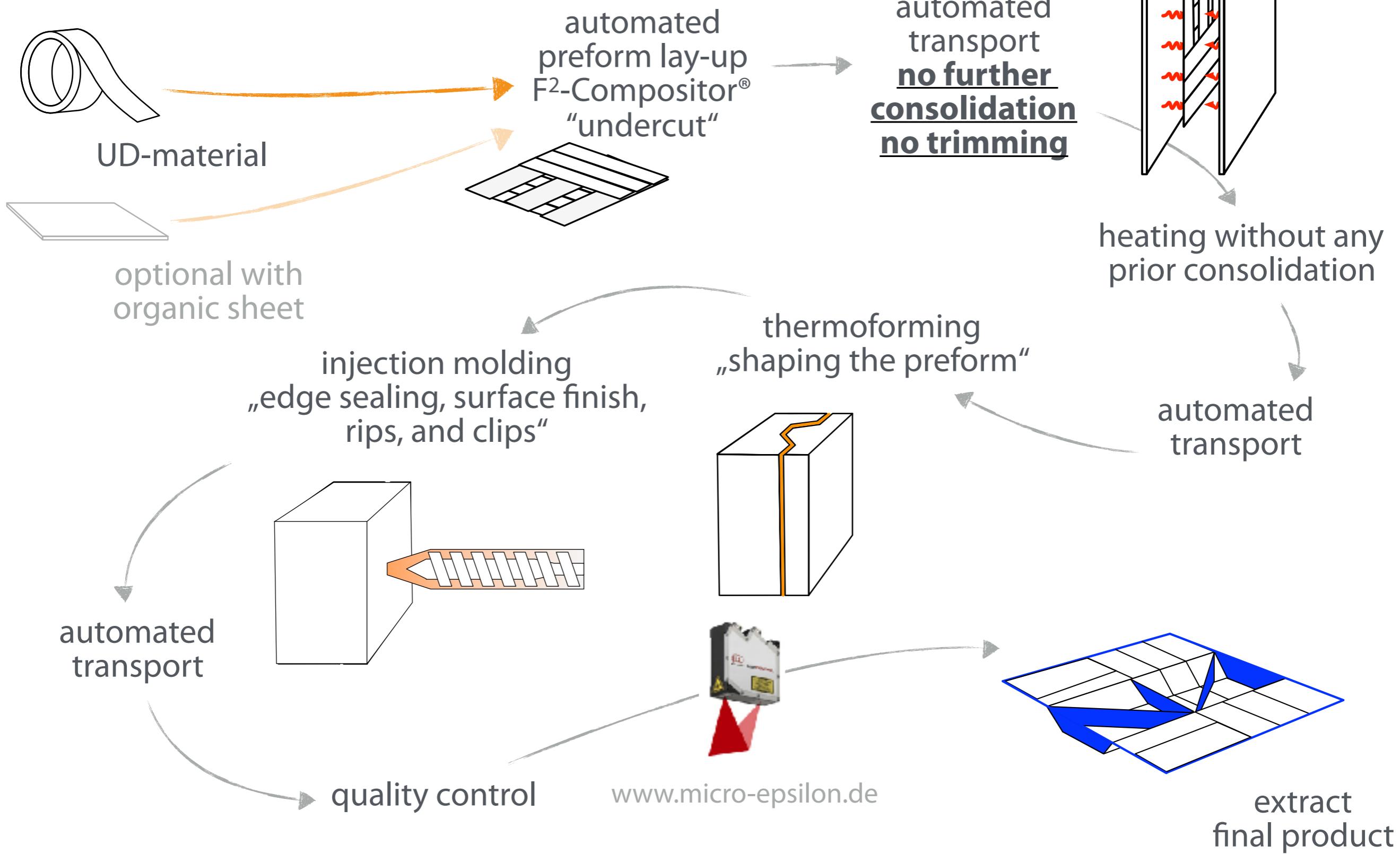
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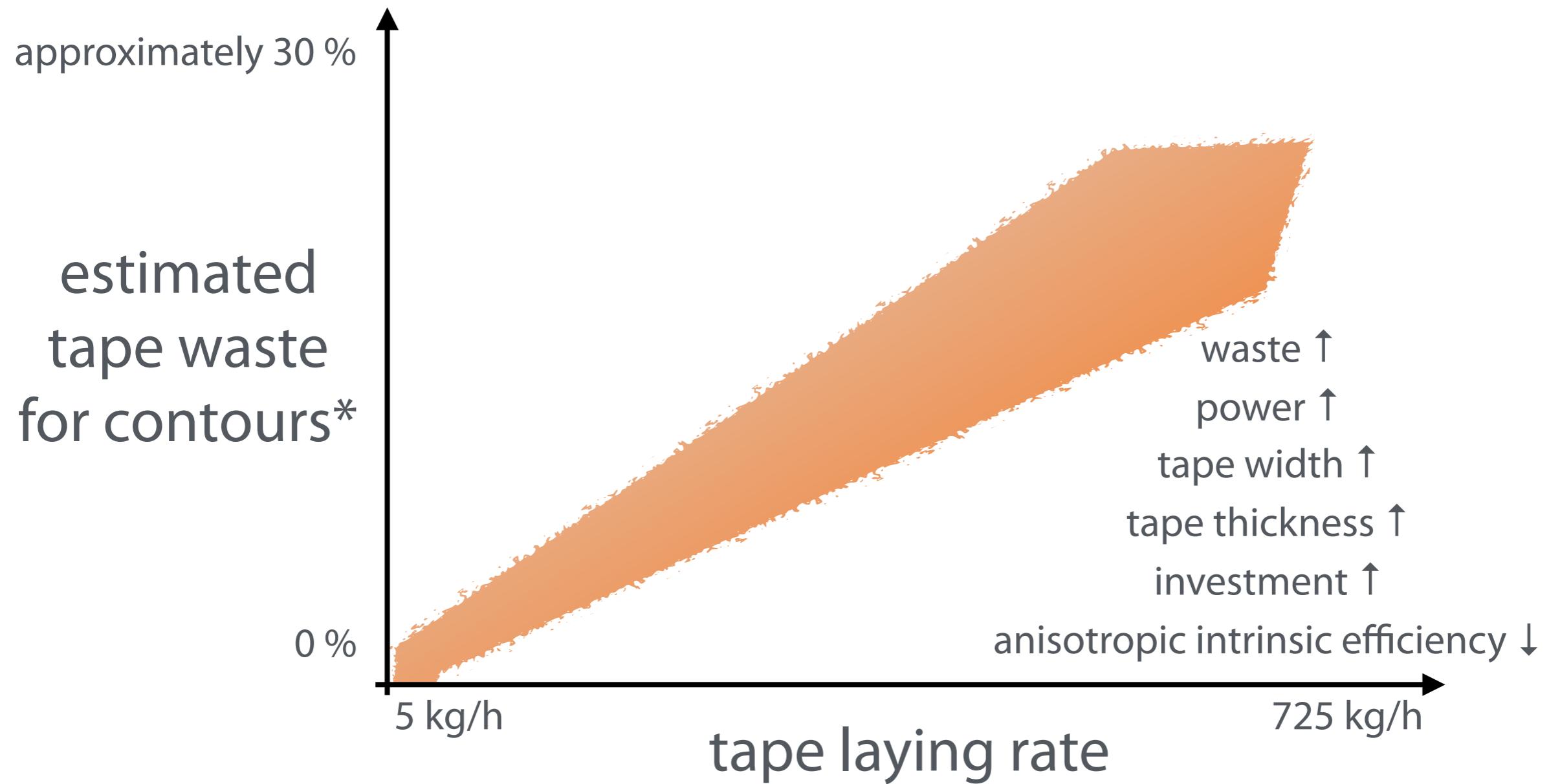


- Staff knowledge base derived from the Institute for Composite Materials (IVW) in Kaiserslautern, Germany
- Experience in thermoplastic winding technology since 1992
 - Design and implementation of 1st application unit for thermoplastic tape placement in 1998
 - Intellectual property in several areas surrounding fiber-placement
 - Support on this topic of:
 - ▶ 5 PhD-thesis
 - ▶ > 25 student research projects
 - ▶ > 40 diploma, bachelor or master thesis
 - ▶ > 10 public research projects
 - ▶ > 30 industrial collaborations
 - Approximately 5 million € of public funding
 - Approximately 5 million € of industrial funding

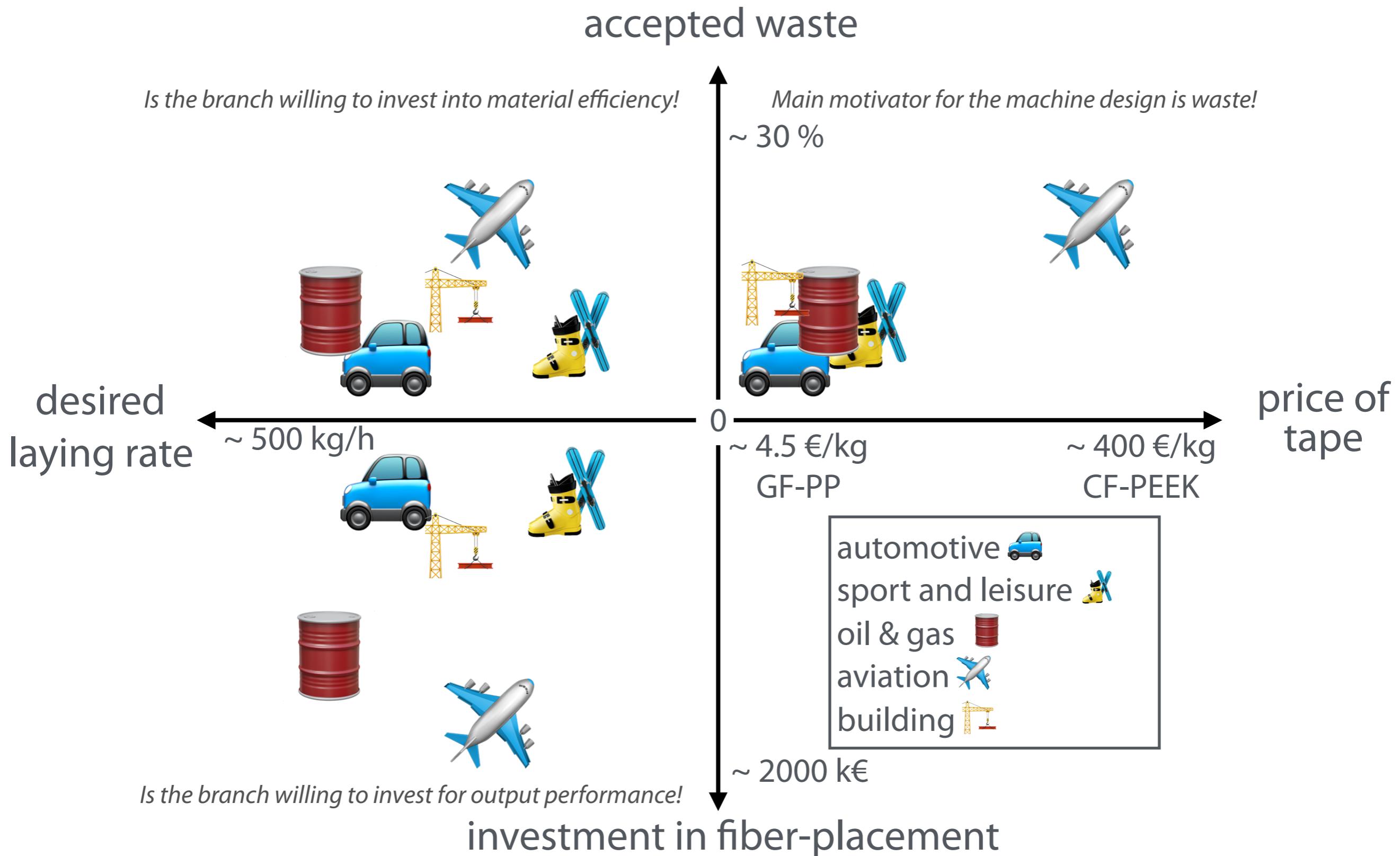
F²-Composite[®], one process scenario for thermoplastic tapes is overmolding



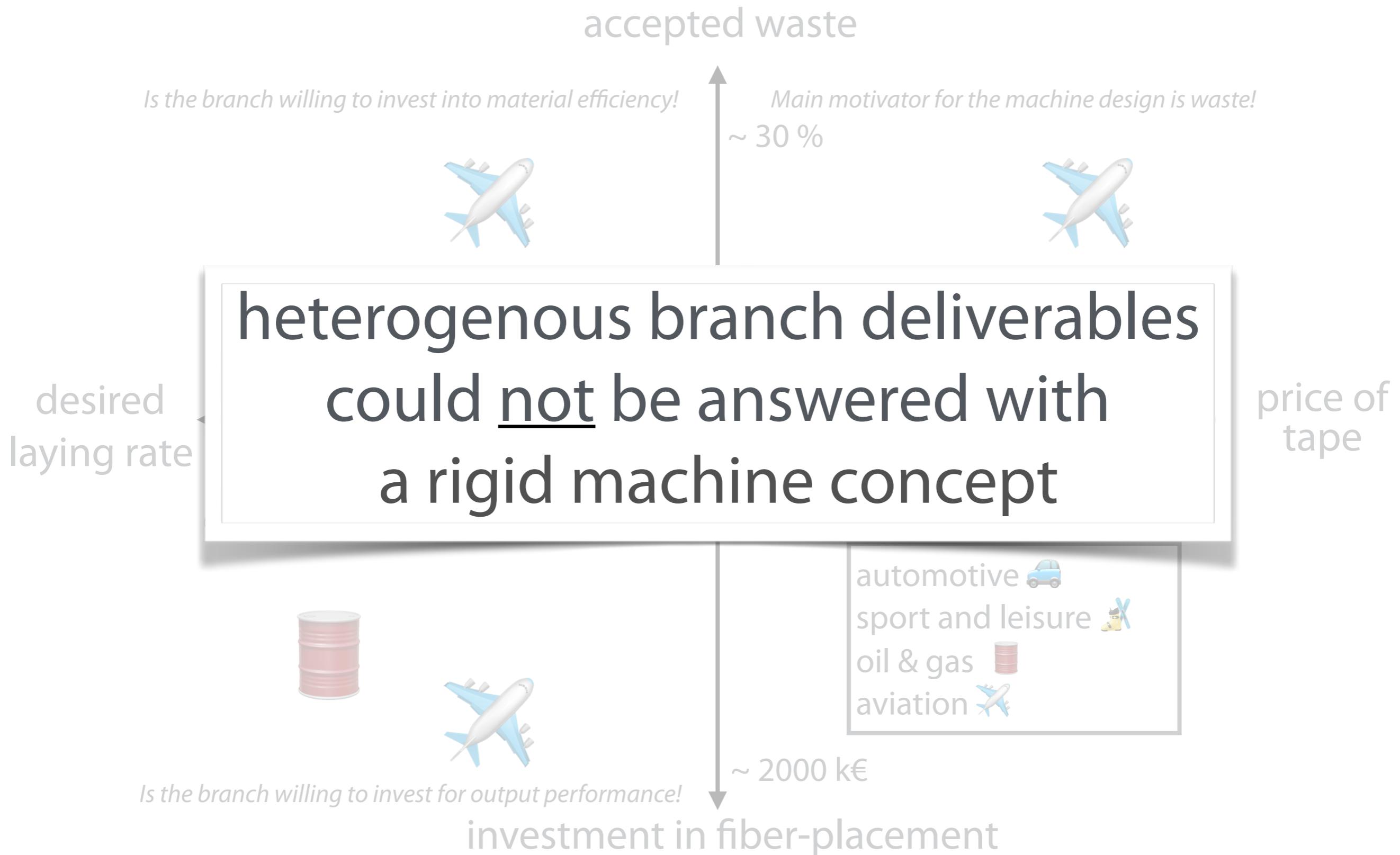
Tape laying rate vs. waste



Market desires, our point of view

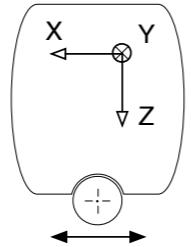


Market desires



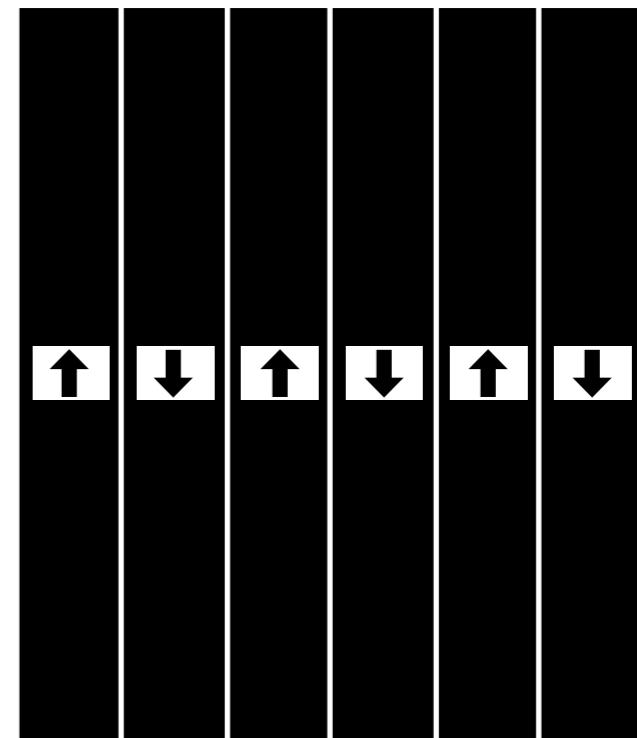
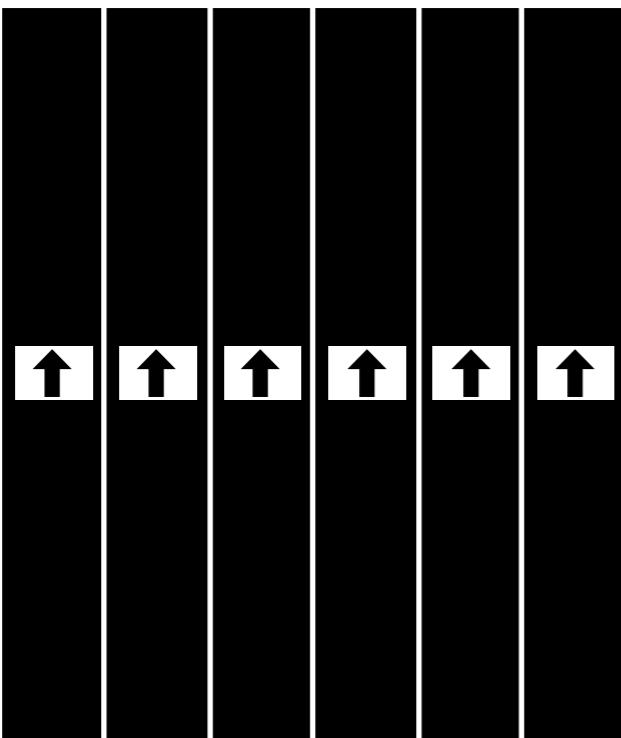
F²-Compositor® design freedom

bidirectional
fiber-placement



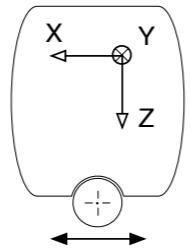
F²-Compositor®

within the scope of geometry and physics



F²-Compositor® design freedom

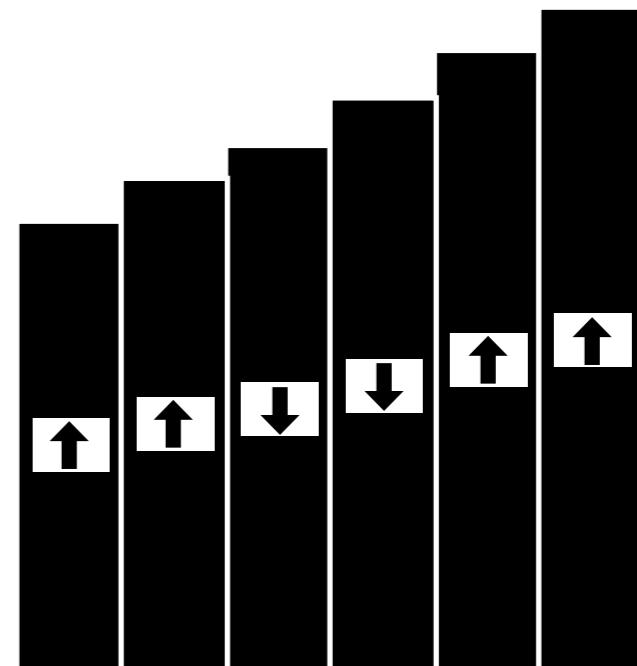
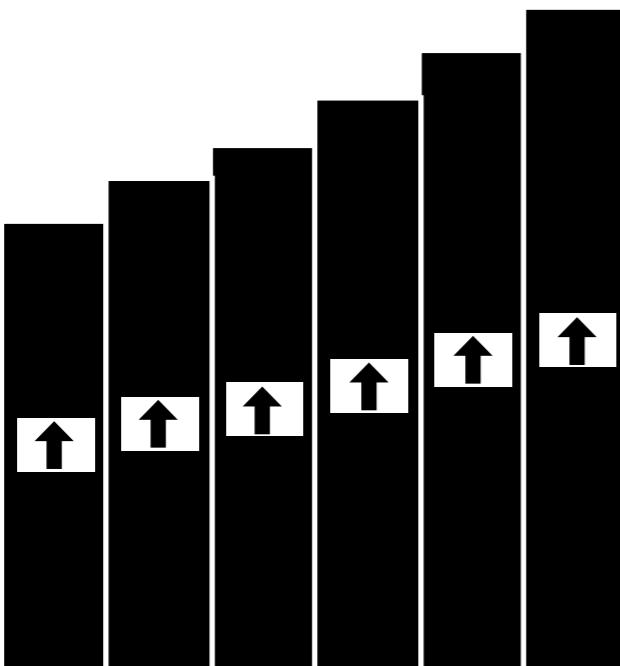
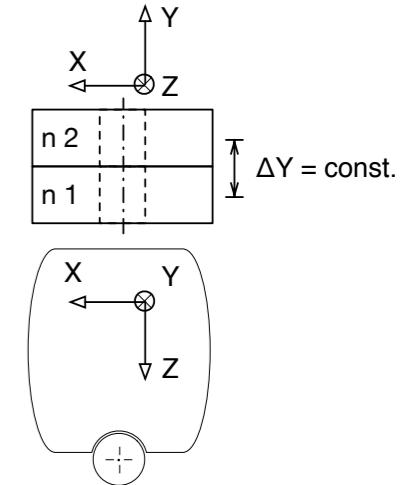
bidirectional
fiber-placement



amount of dependent
application units

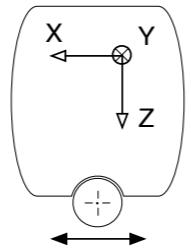
F²-Compositor®

within the scope of geometry and physics

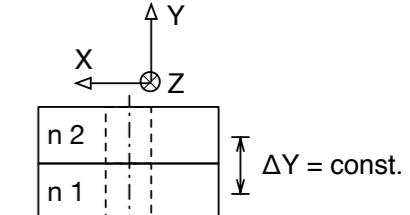


F²-Compositor® design freedom

bidirectional
fiber-placement



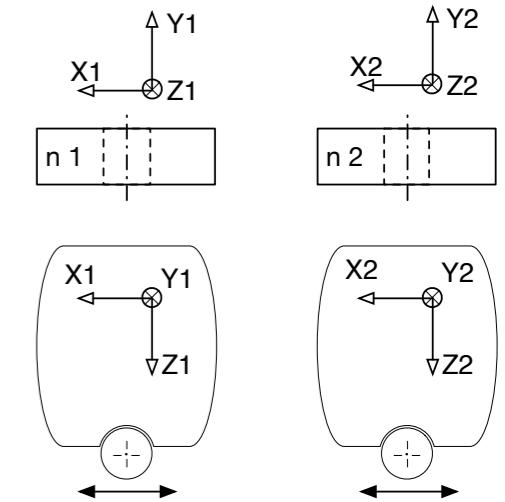
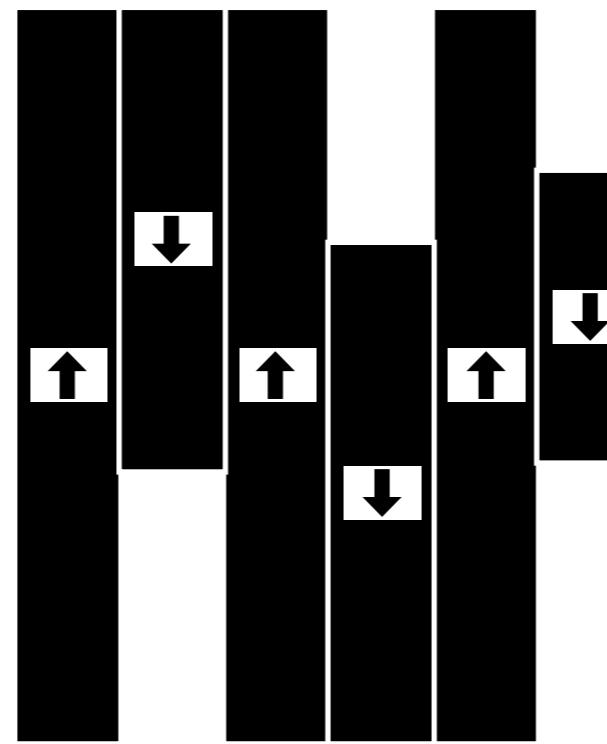
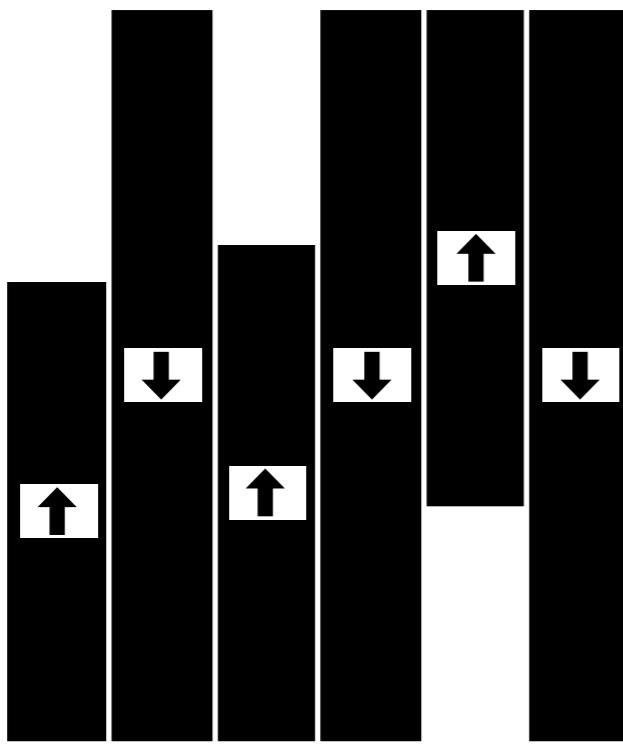
amount of dependent
application units



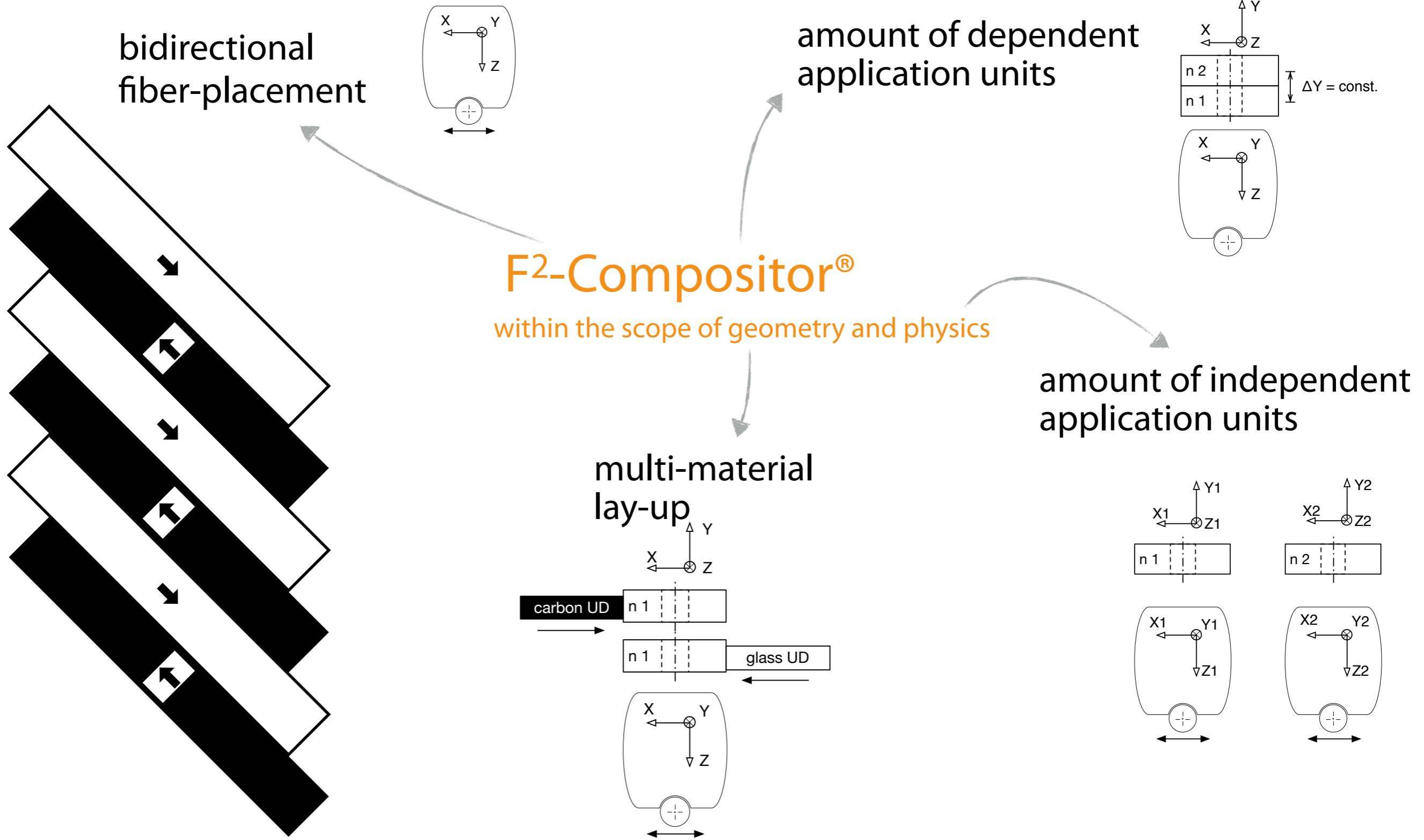
F²-Compositor®

within the scope of geometry and physics

amount of independent
application units

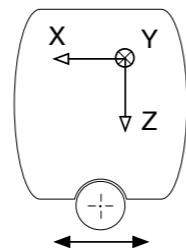


F²-Compositor® design freedom

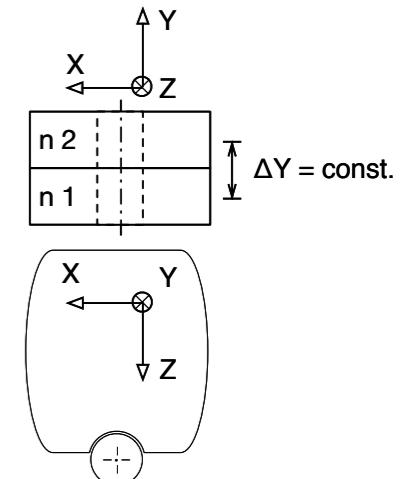


F²-Compositor® design freedom

bidirectional
fiber-placement

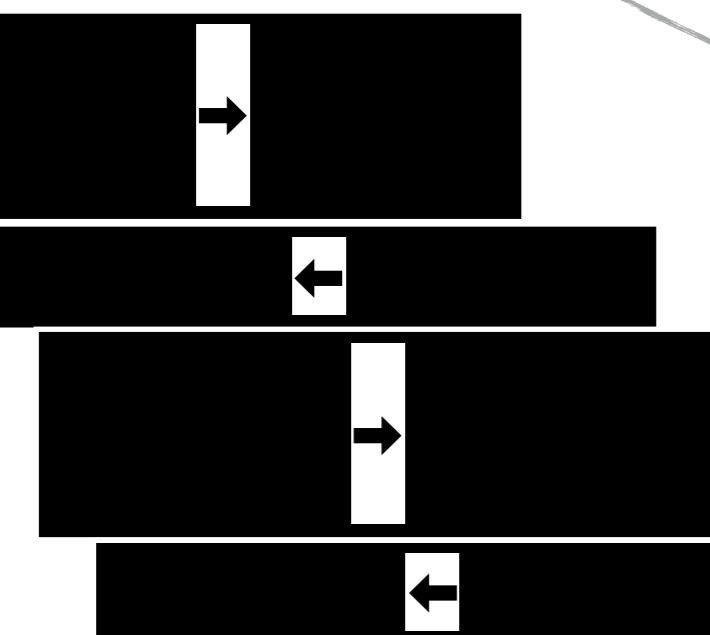


amount of dependent
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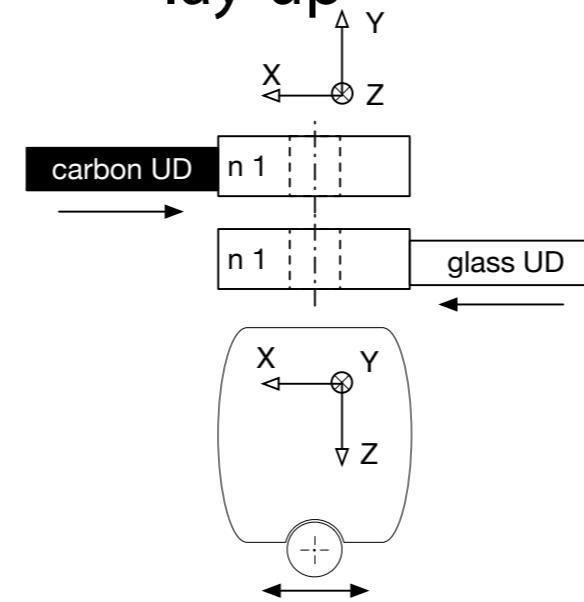


F²-Compositor®

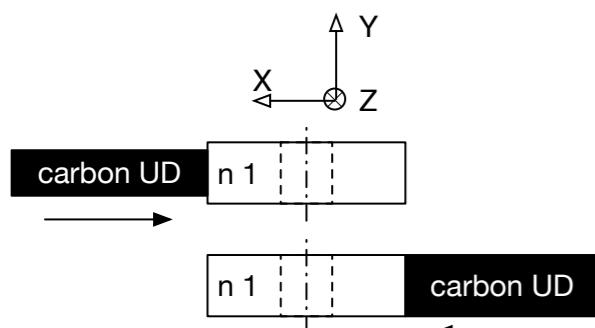
within the scope of geometry and physics



multi-material
lay-up

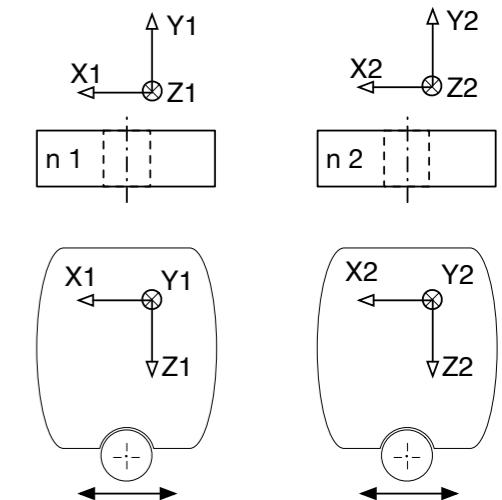


multi-cross sections



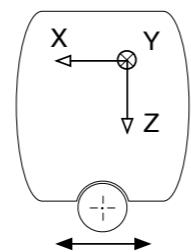
width 1 ≠ width 2
thickness 1 ≠ thickness 2

amount of independent
application units

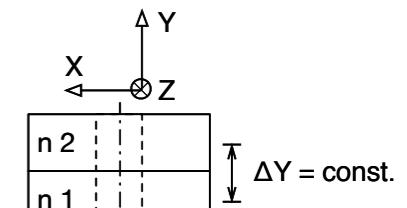


F²-Compositor® design freedom

bidirectional
fiber-placement



amount of dependent
application units



automated quality control
of the material/preform

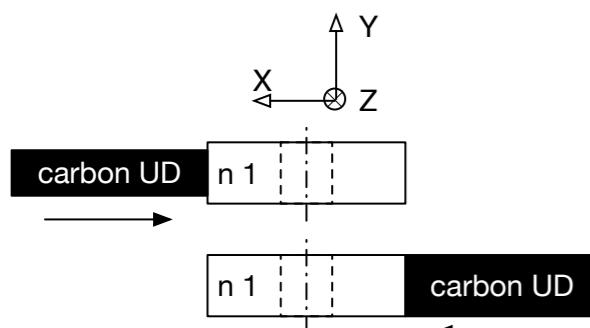


www.micro-epsilon.de

F²-Compositor®

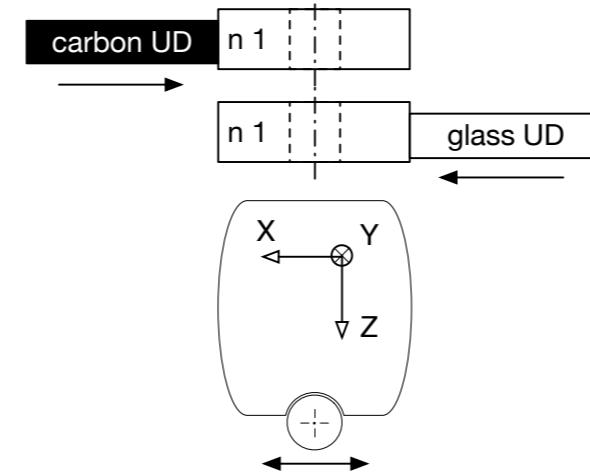
within the scope of geometry and physics

multi-cross sections

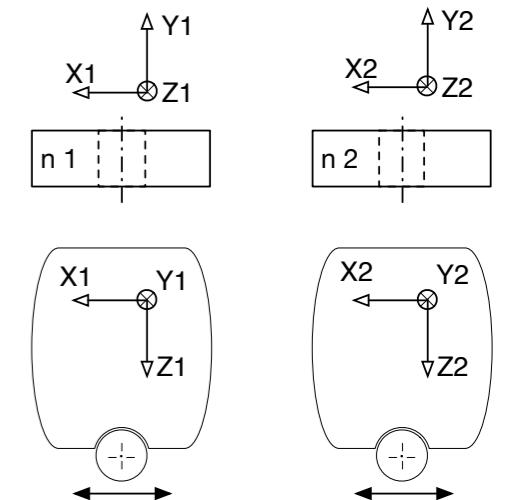


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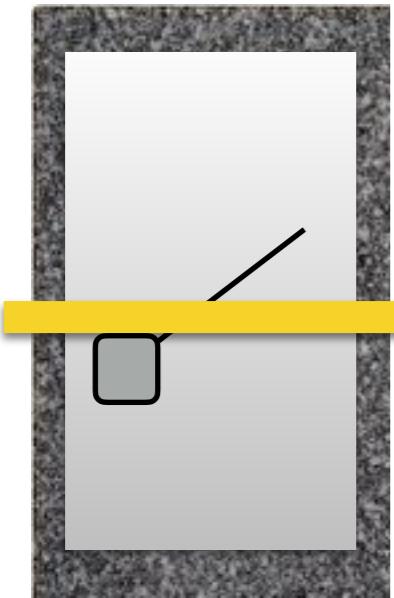
multi-material
lay-up



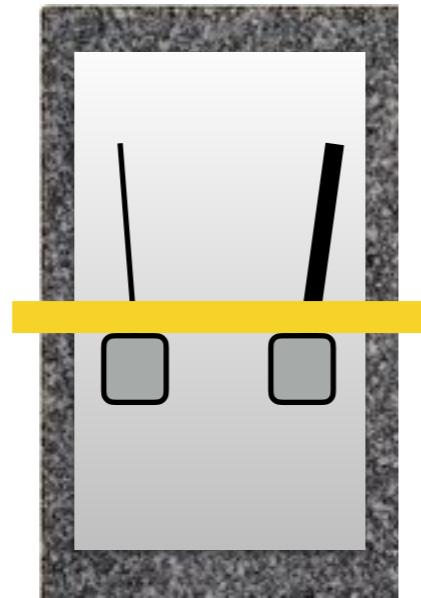
amount of independent
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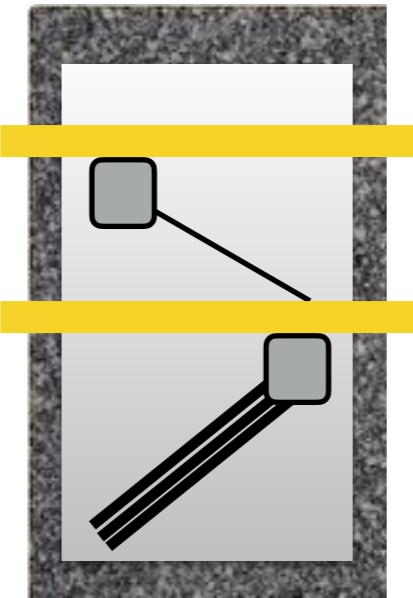
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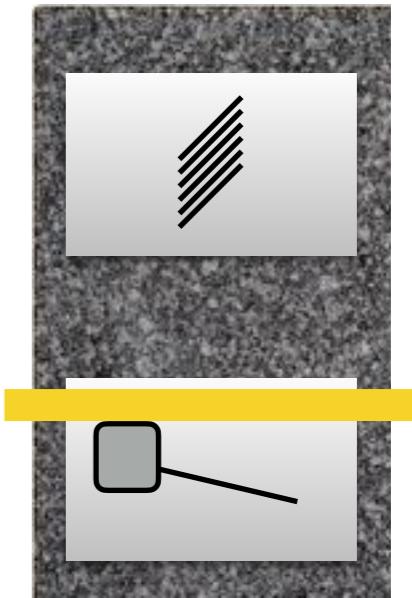
simplex or duplex



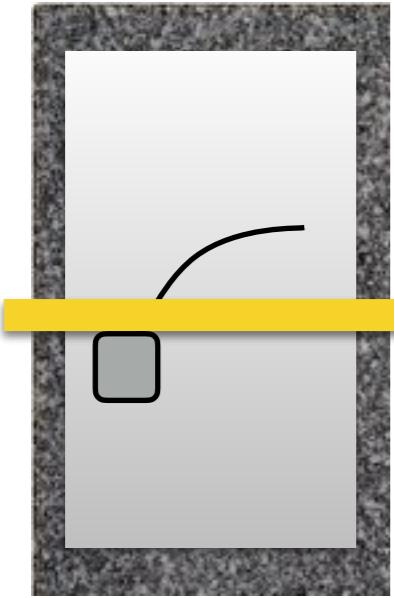
multiple application units



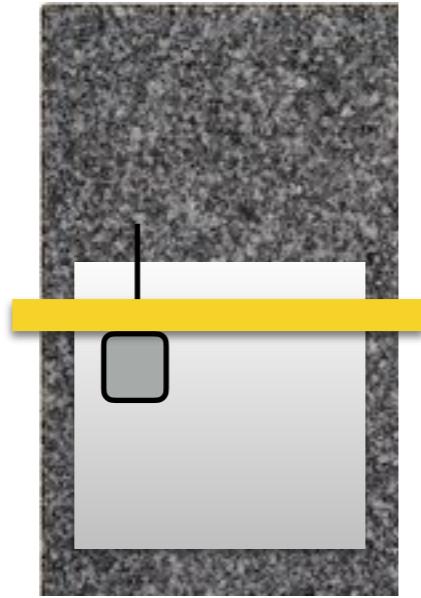
multiple application units and parallelization



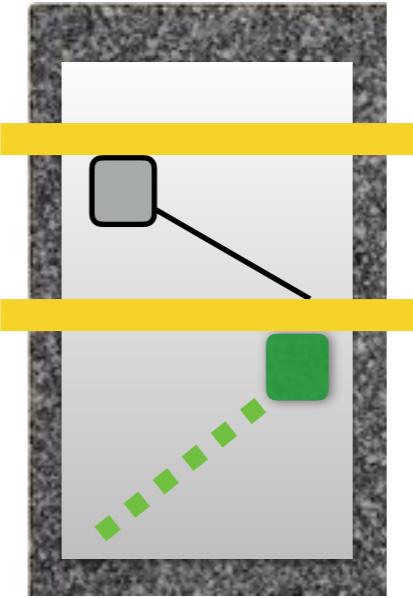
pendulum operation



curved path



tool movement or conveyor movement



mixing technology,
e.g. rapid prototyping

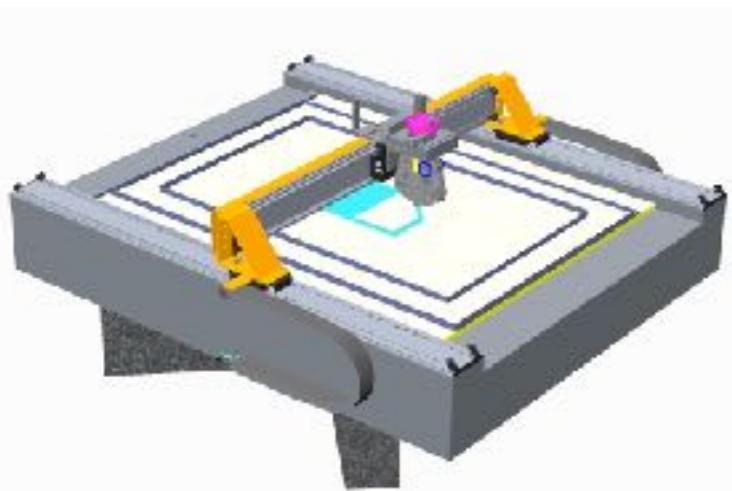


focusing on near UD

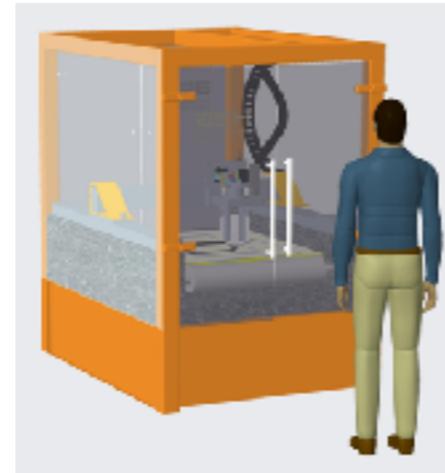


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F²-Compositor® design freedom



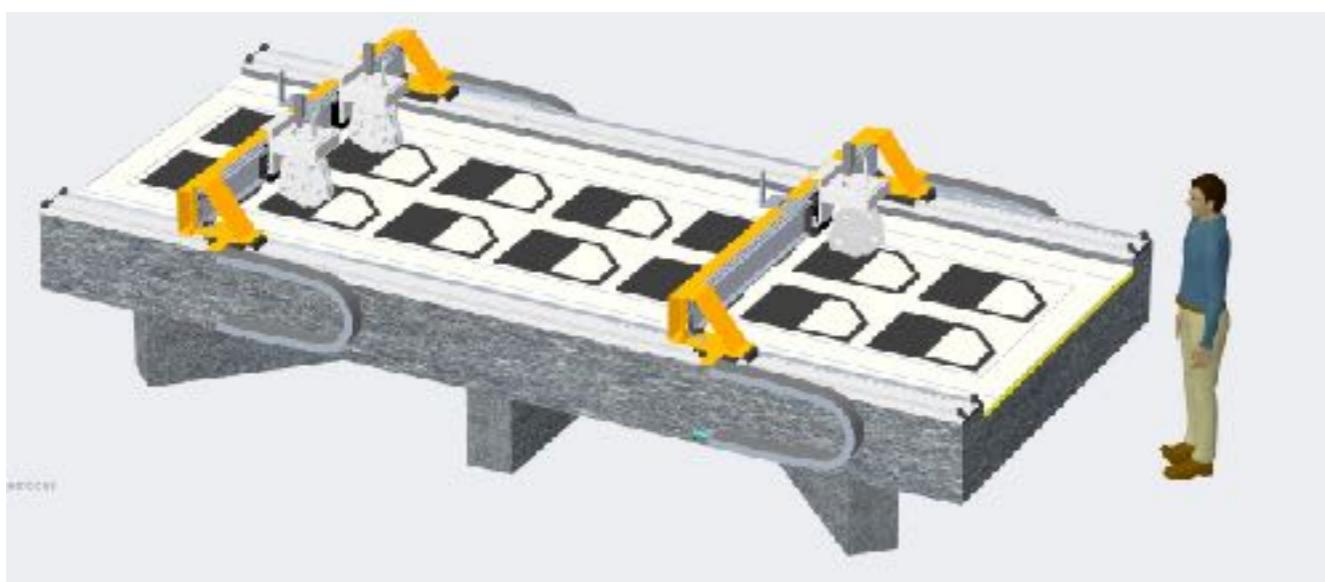
tape placement, flexible tape width
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dimension 4 m x 2.65m*



tape placement, tape winding and both
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dimension 1.9 m x 1.4 m



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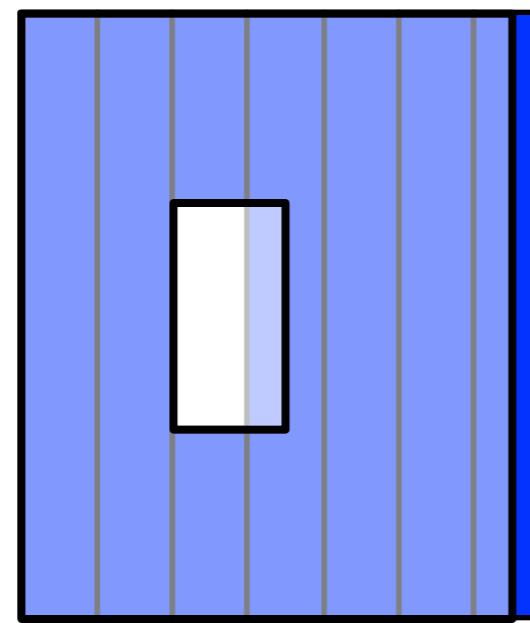
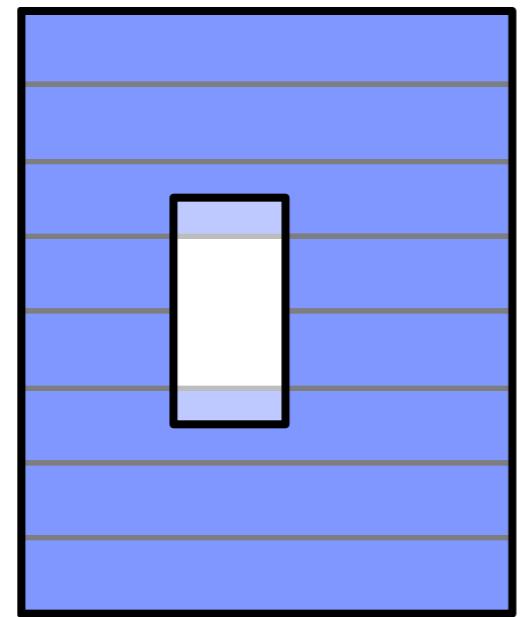
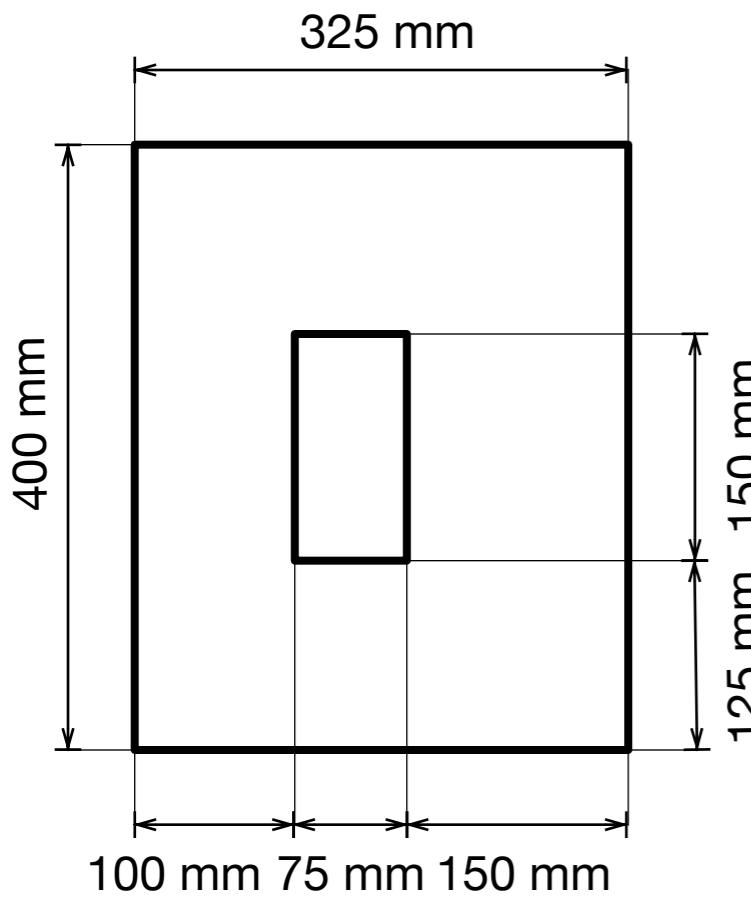
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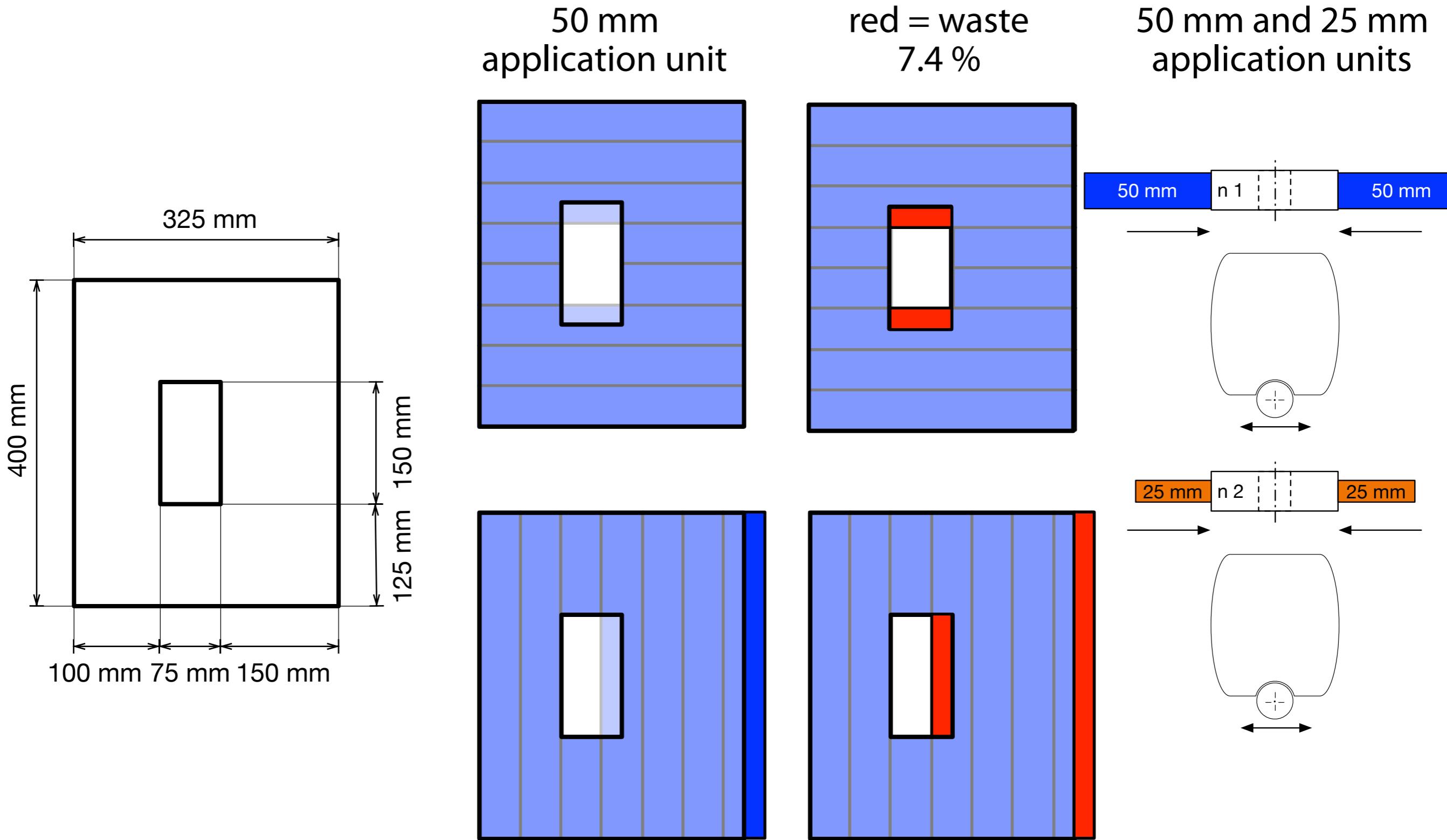
tape placement, fixed tape width,
material supply on board
F²-Compositor LabCube
dimension 0.9 m x 0.8 m

Option to reduce waste

50 mm
application unit

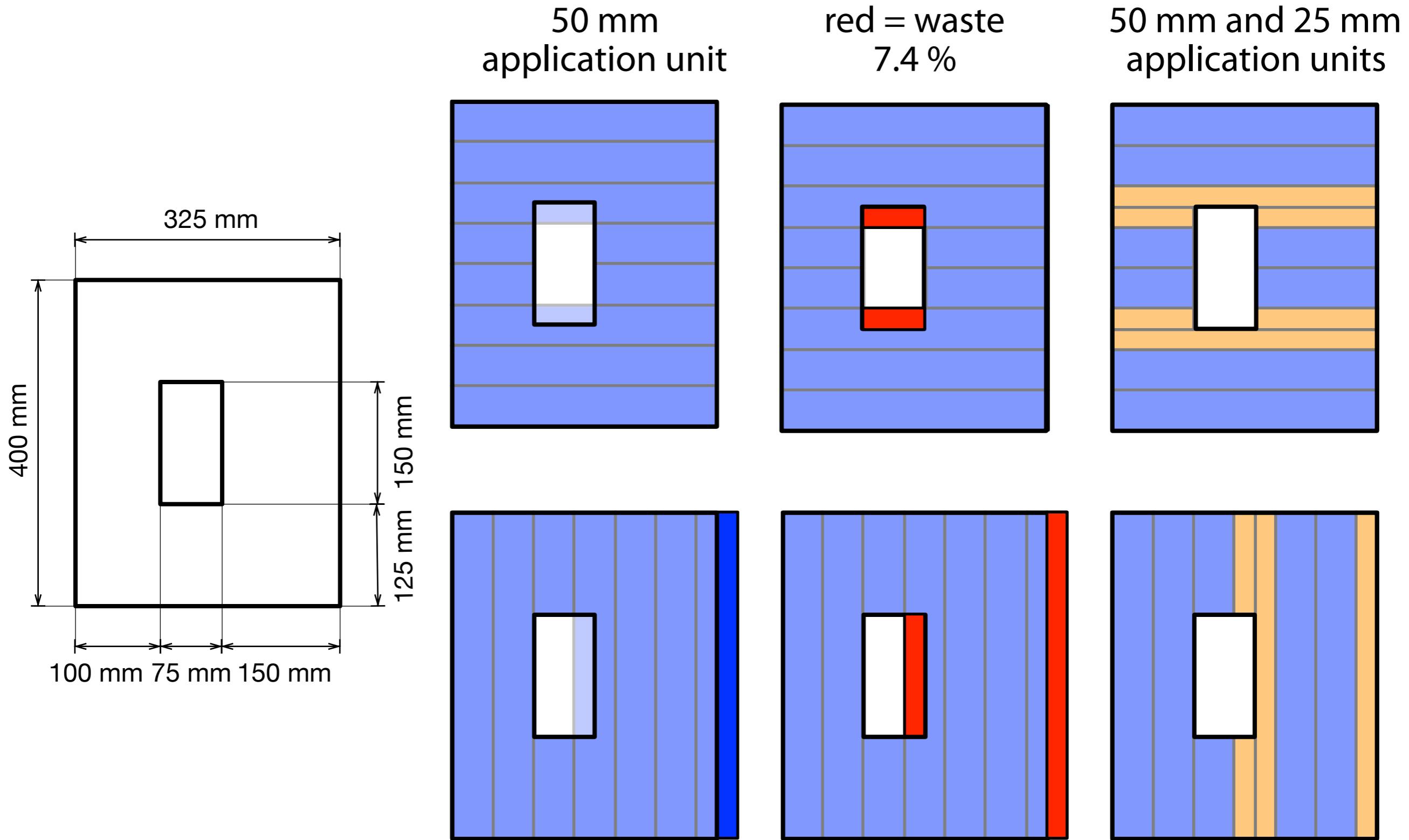


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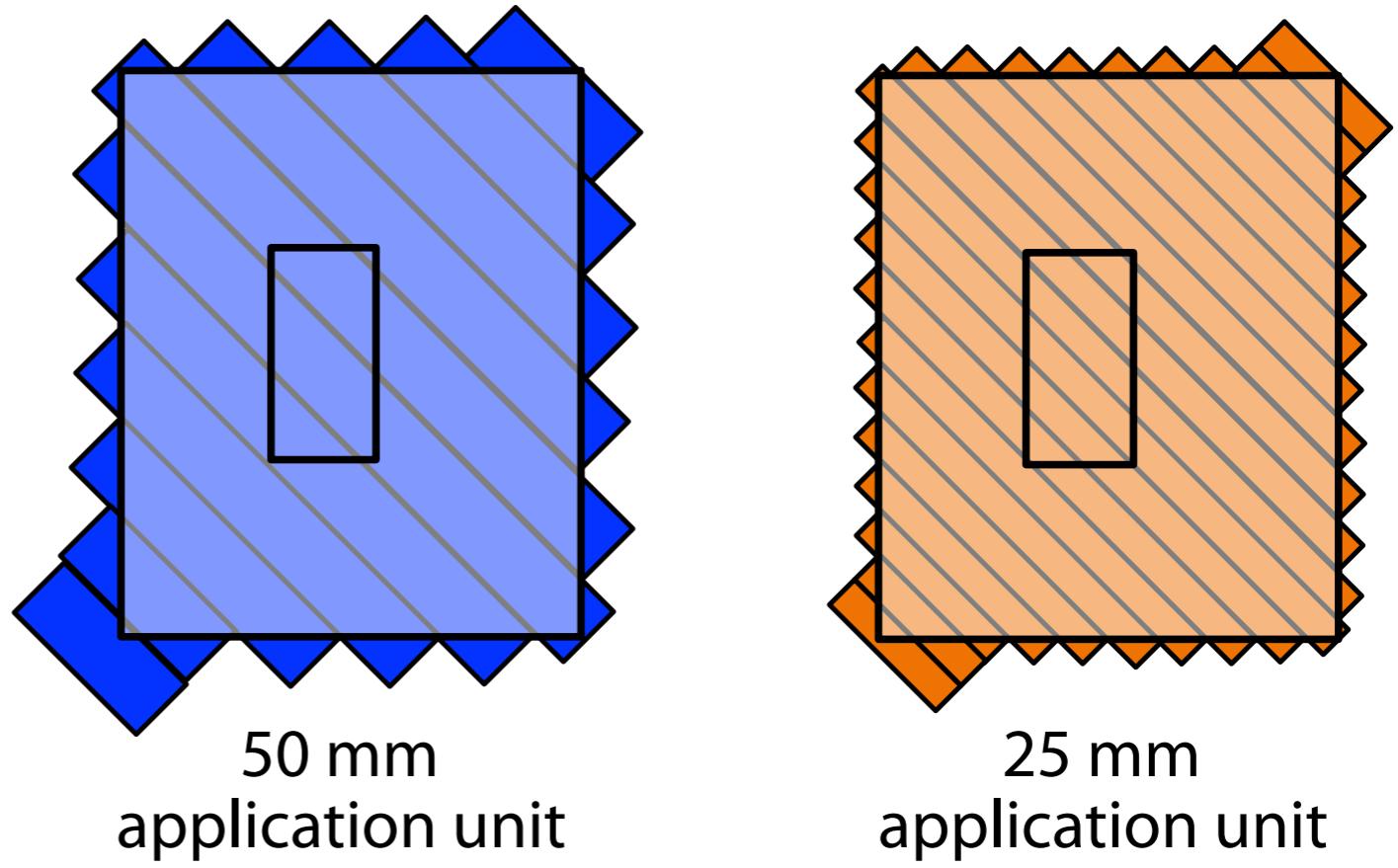
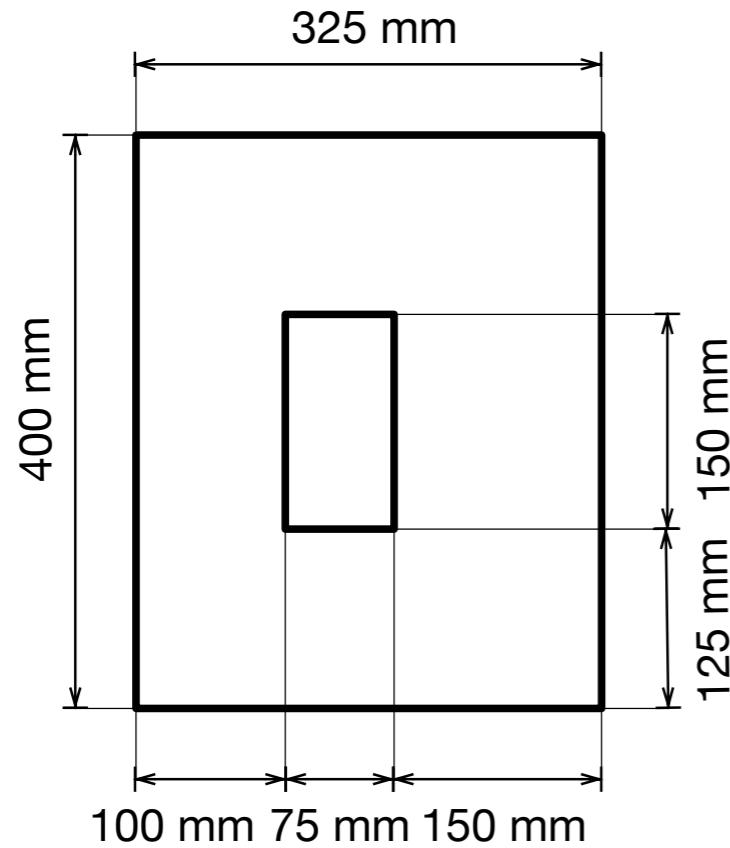


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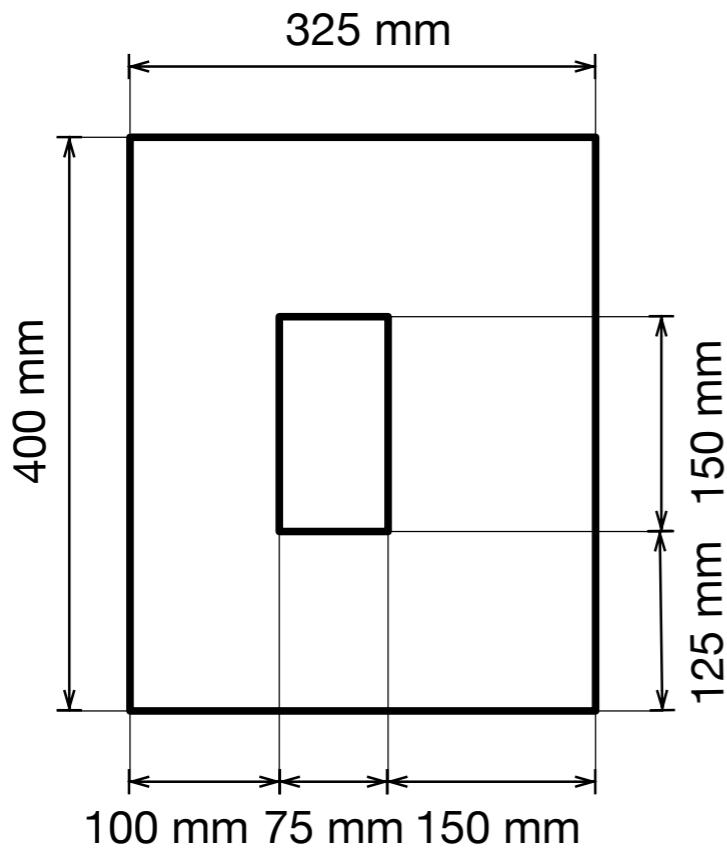
Multiple tape geometries



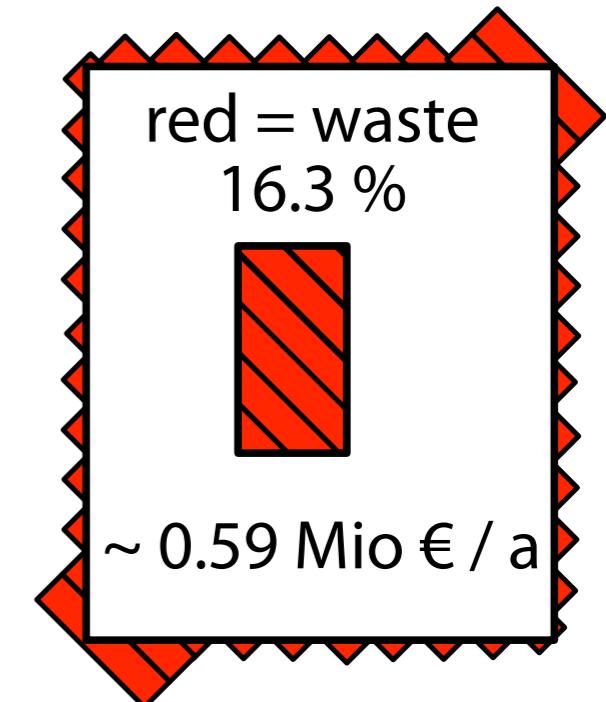
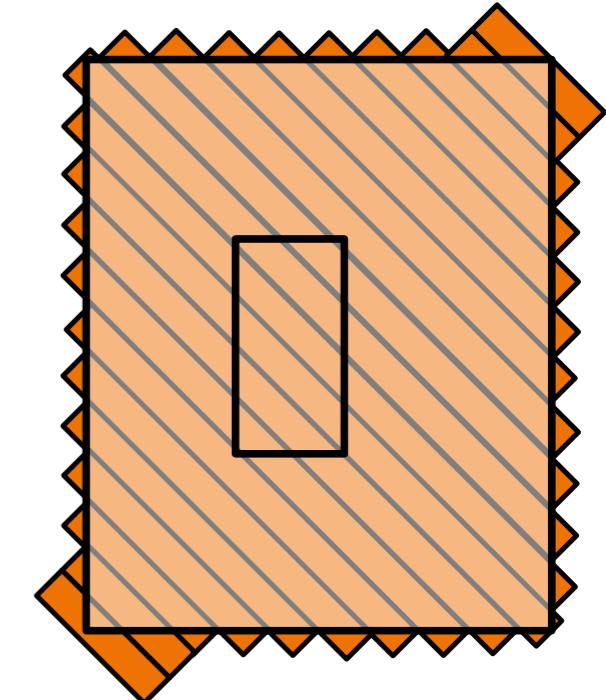
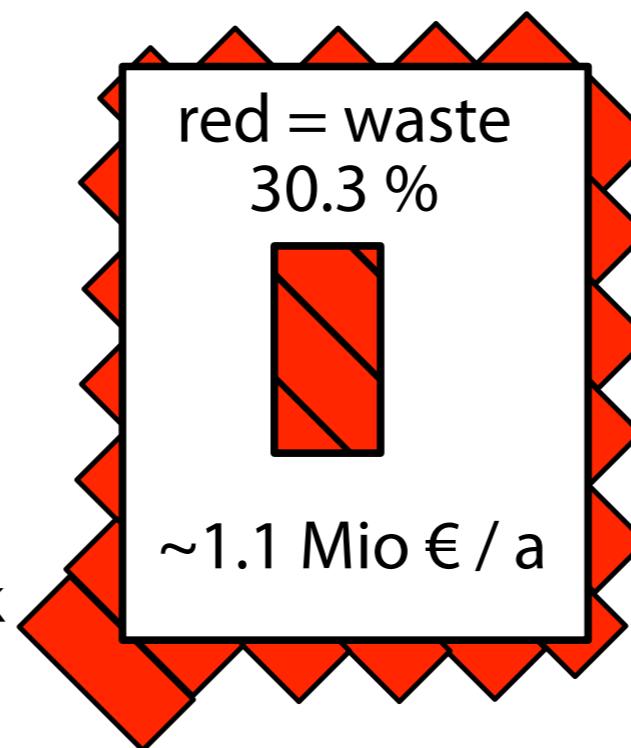
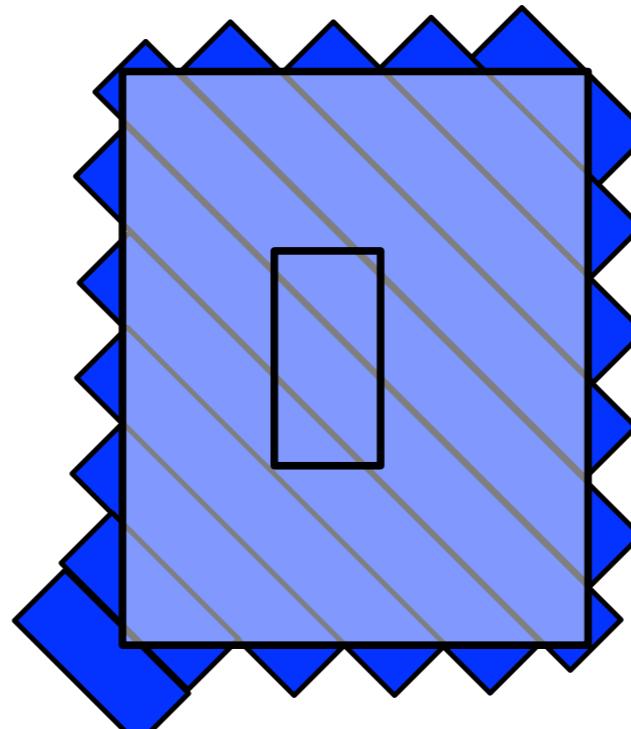
Option to reduce waste



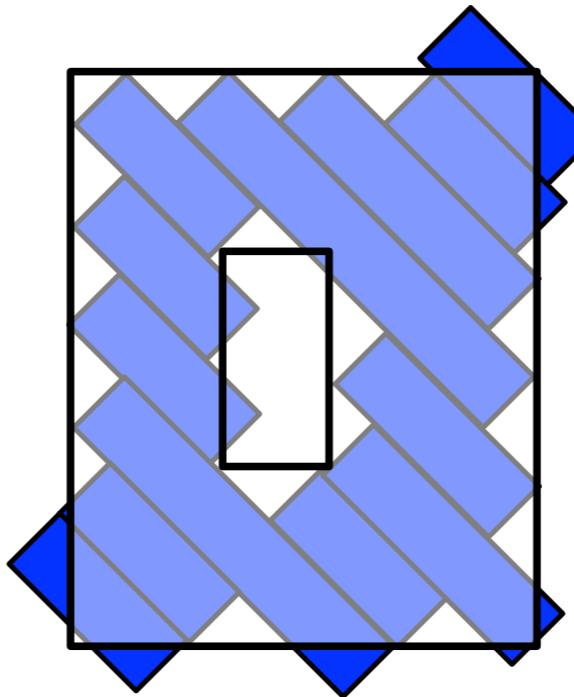
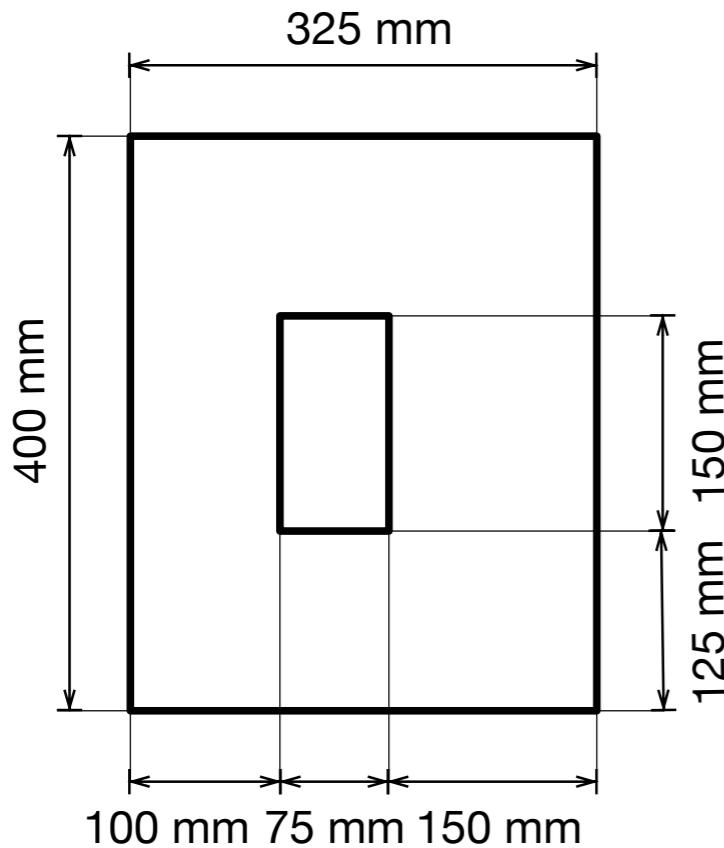
Minimize waste



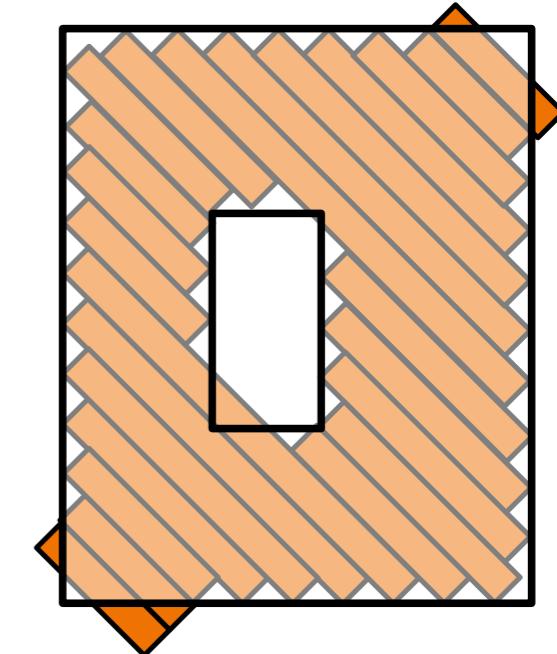
CF-PPS
55 Fvol-%
200 € /kg
2 mm thick
50.000 / a



Option to reduce waste Near net shape + injection moulding

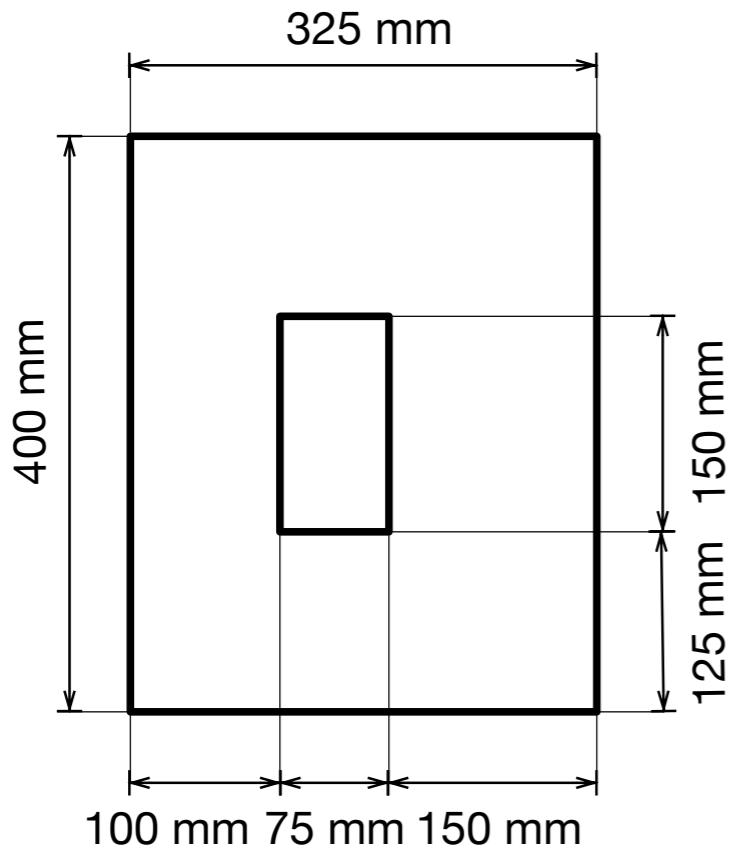


50 mm
application unit

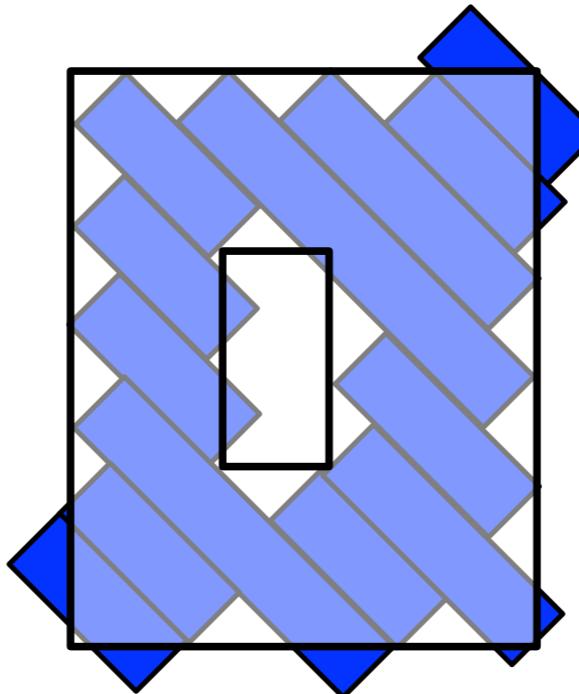


25 mm
application unit

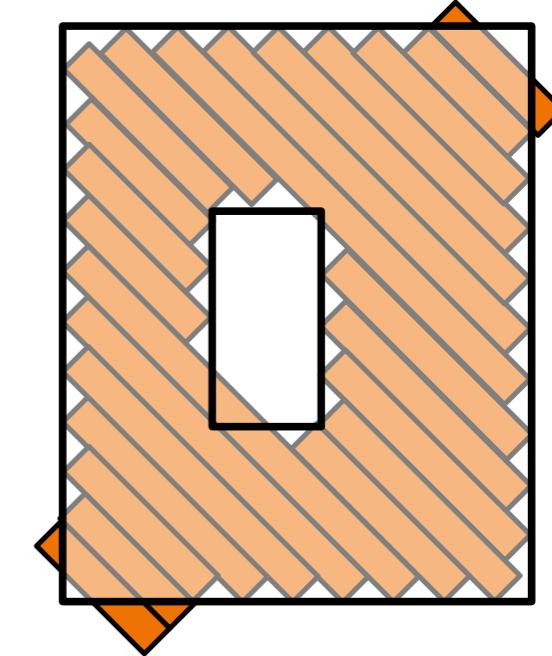
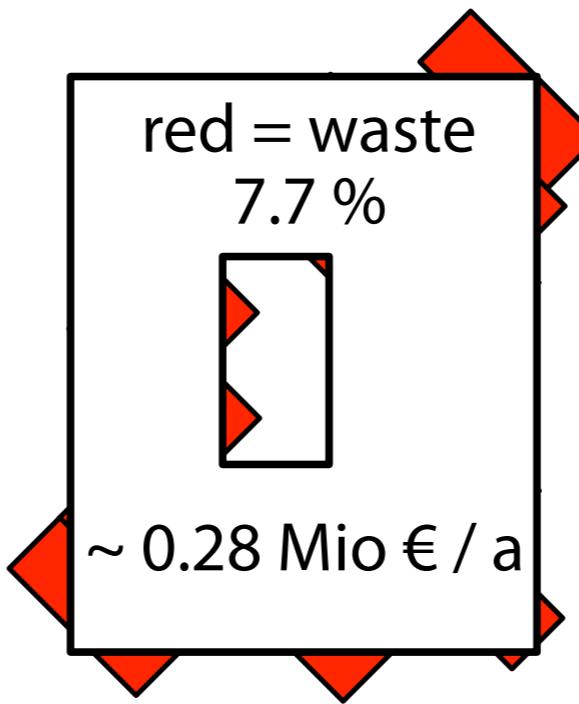
Minimize waste Near net shape + injection moulding



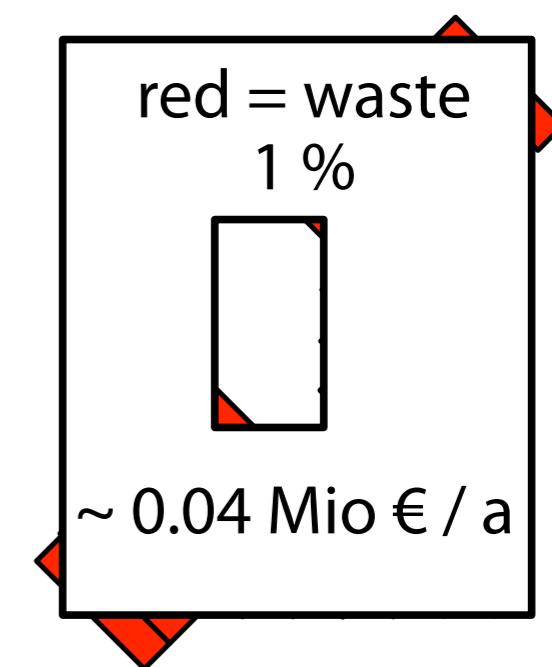
CF-PPS
55 Fvol-%
200 € / kg
2 mm thick
50.000 / a



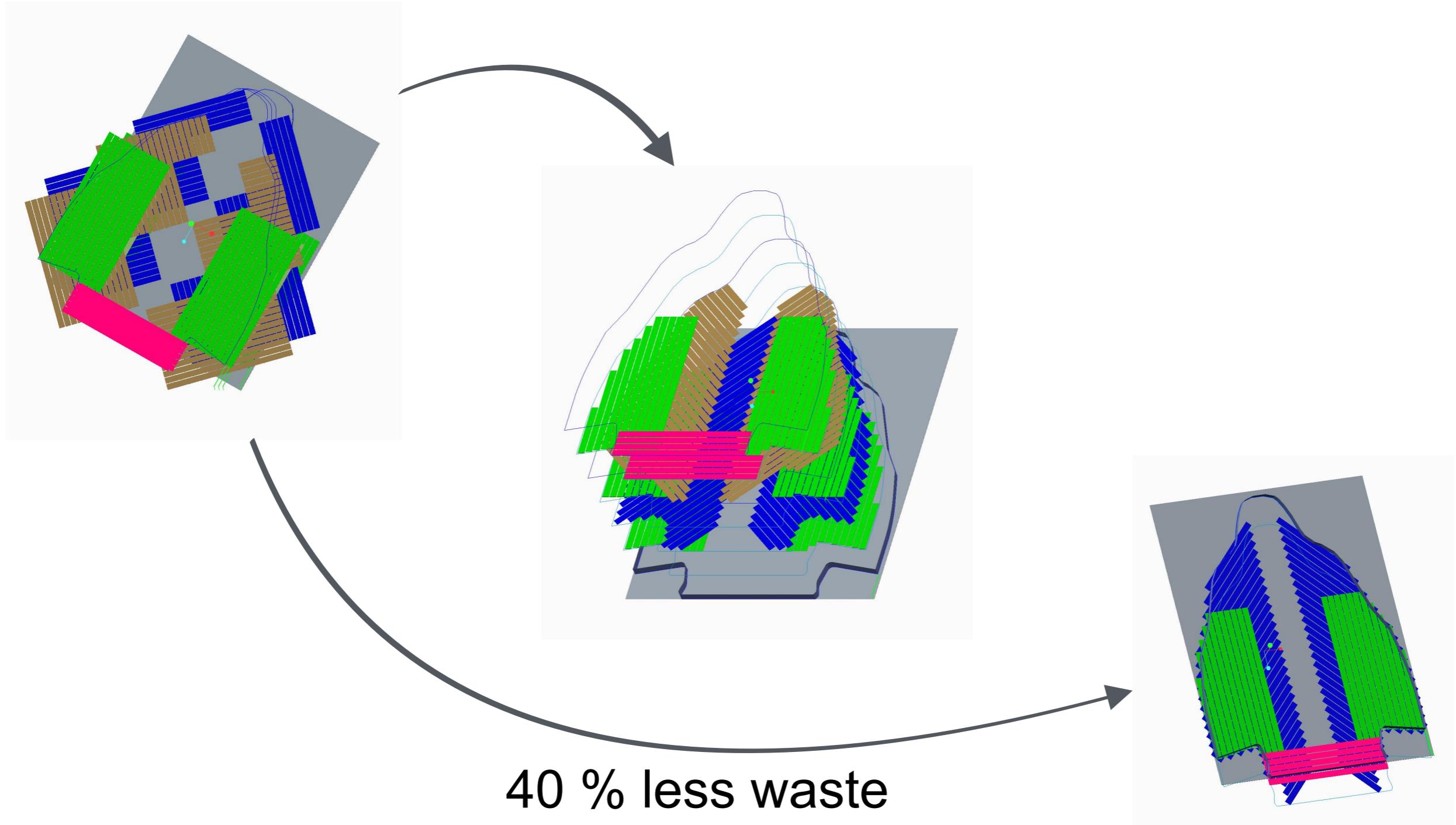
50 mm
application unit



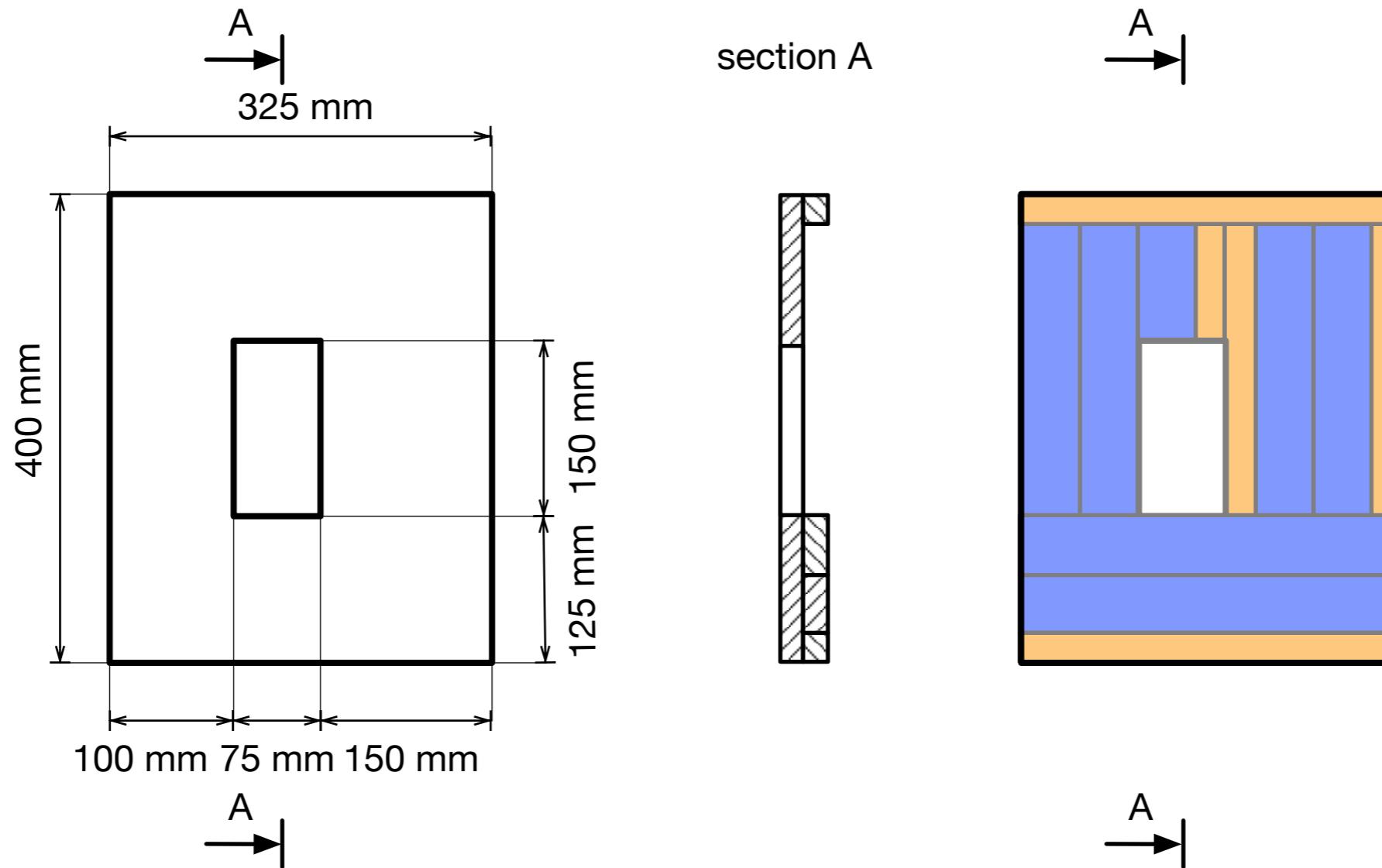
25 mm
application unit



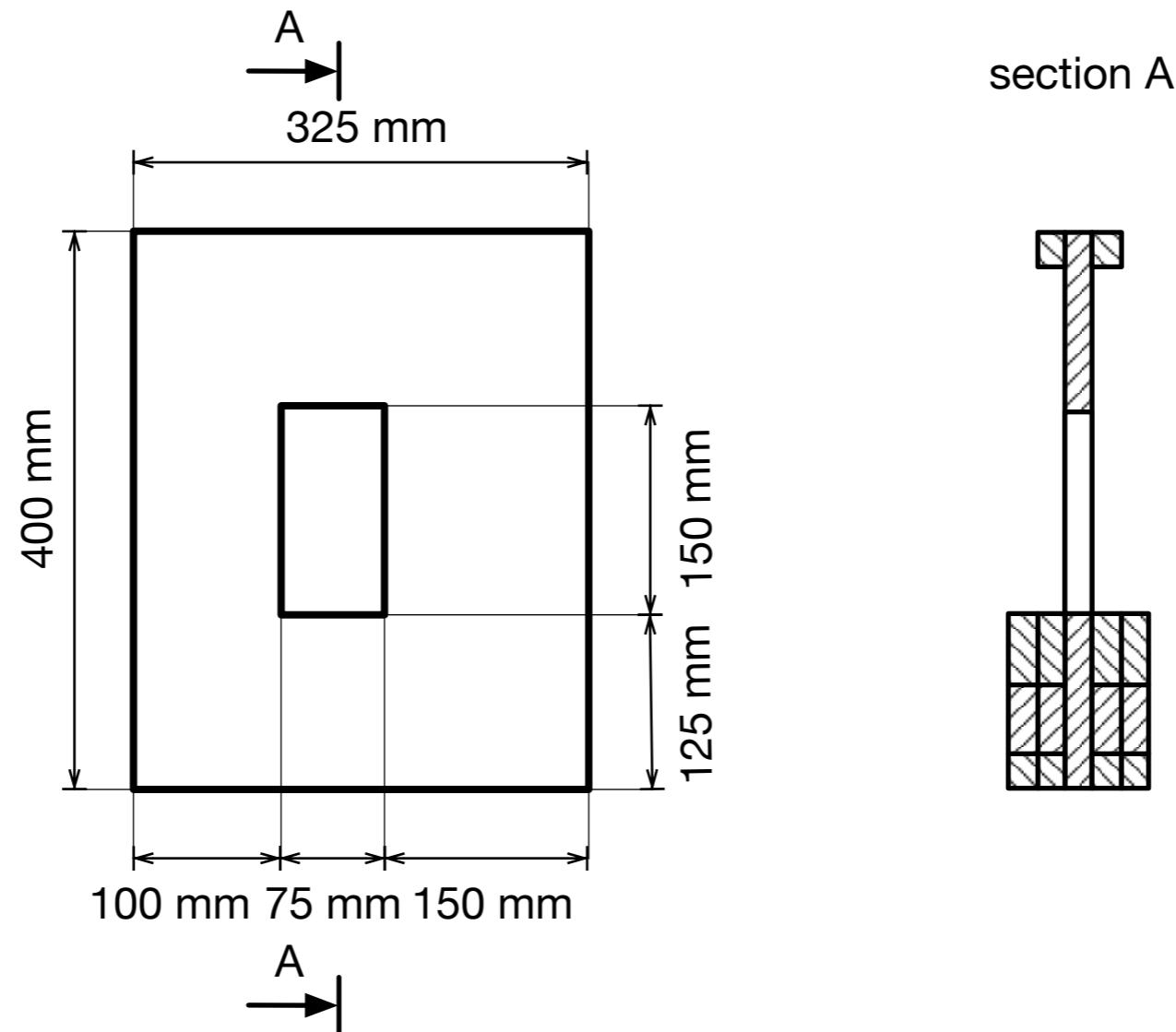
F²-Composite® Automotive scenario, seat structure



F²-Composite® Flexible sections



Flexible sections

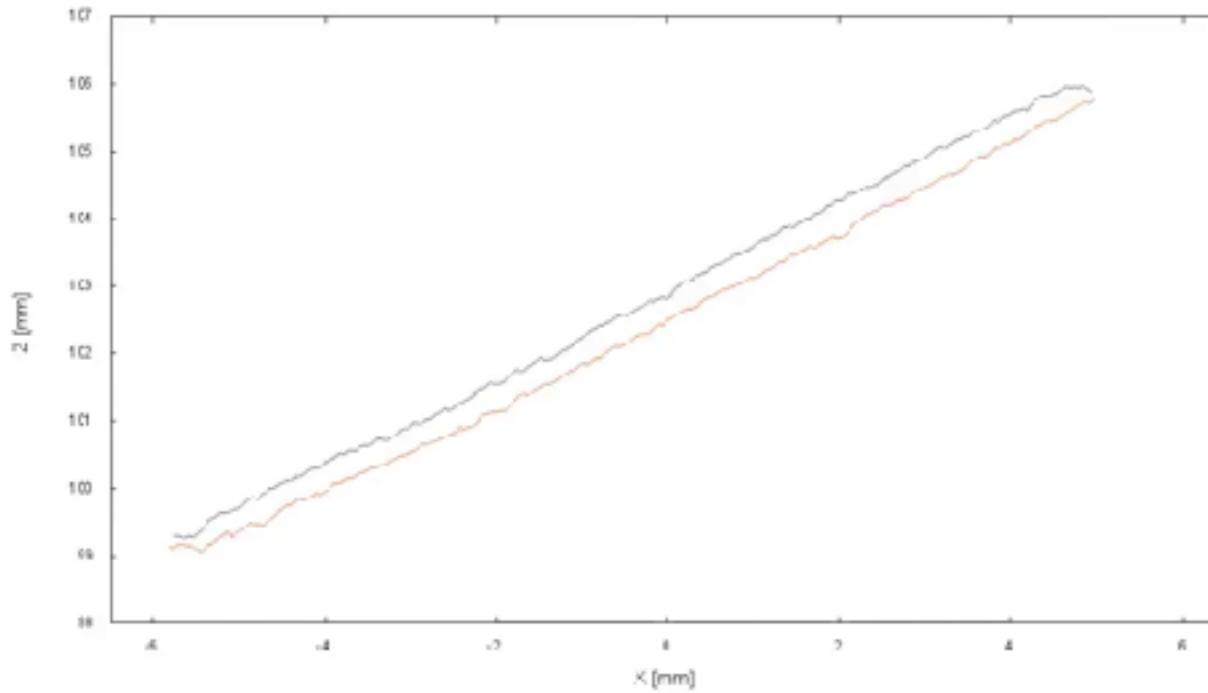


within the scope of geometry and physics

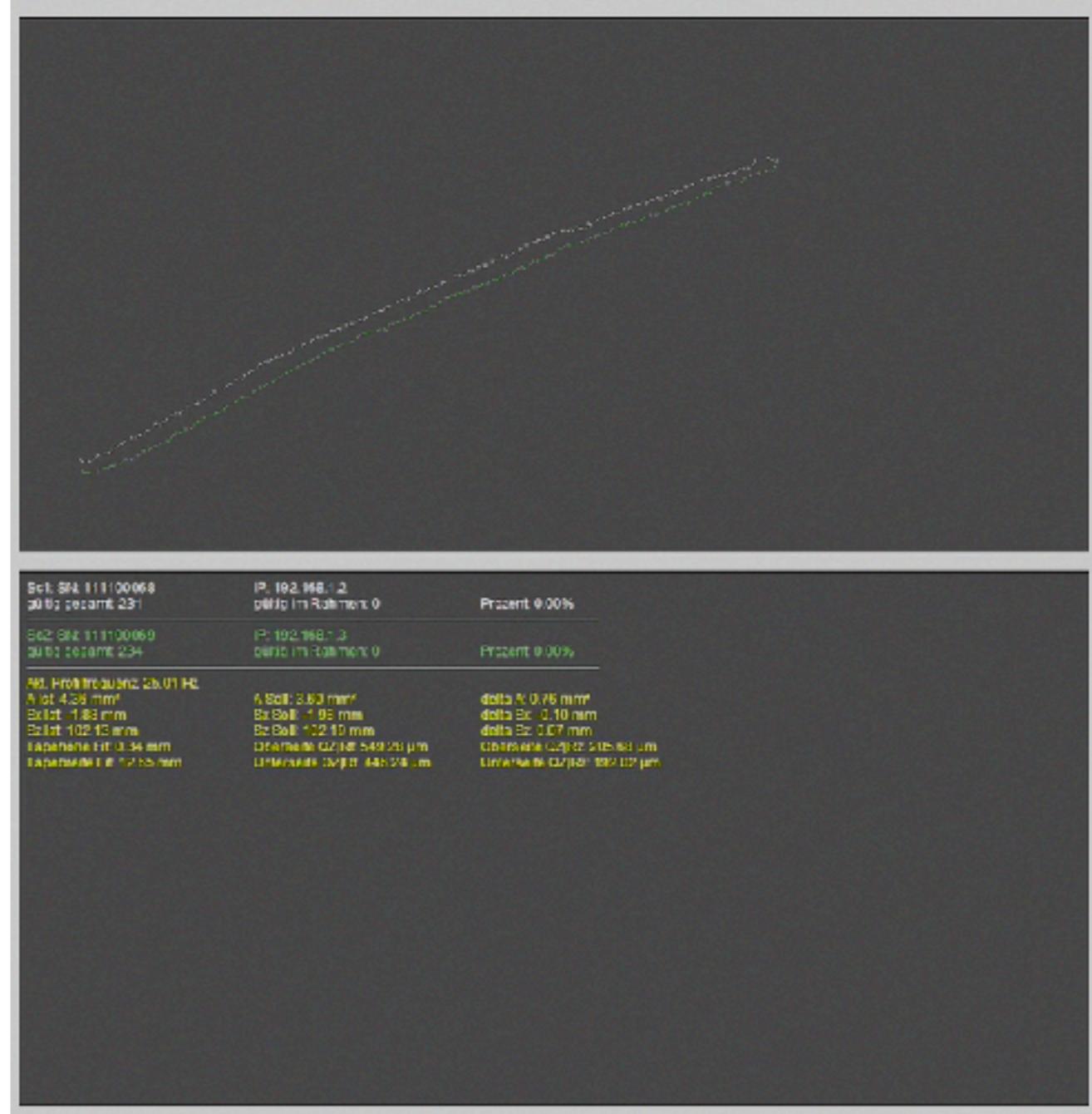
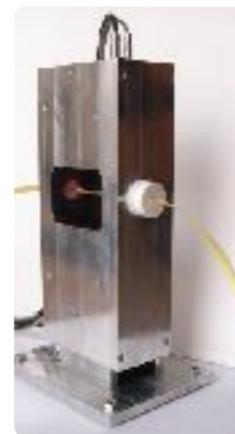
What is the difference?

- We do not buy robots, we built them!
- We have our own customized drives!
- We have a single control unit, covering all processes!
- We have a much cheaper heating source!
- We do not use a laser, causing secondary costs for safety equipment and safety education!
- We generate the polymer melt only in the joining zone, so we have an energy efficient heating process!
- We use an energy recovery system to store and release the motion energy, especially on short tracks!
- We do not have a huge overhead!

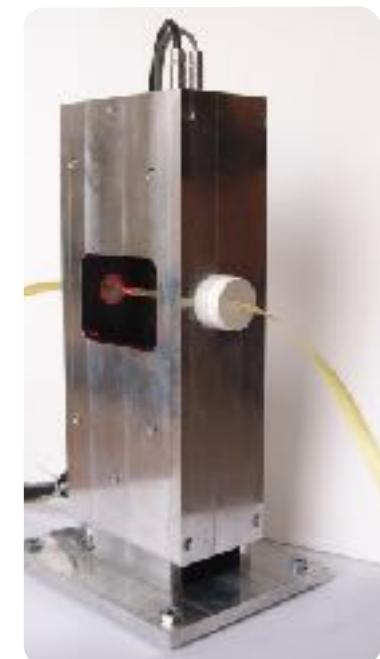
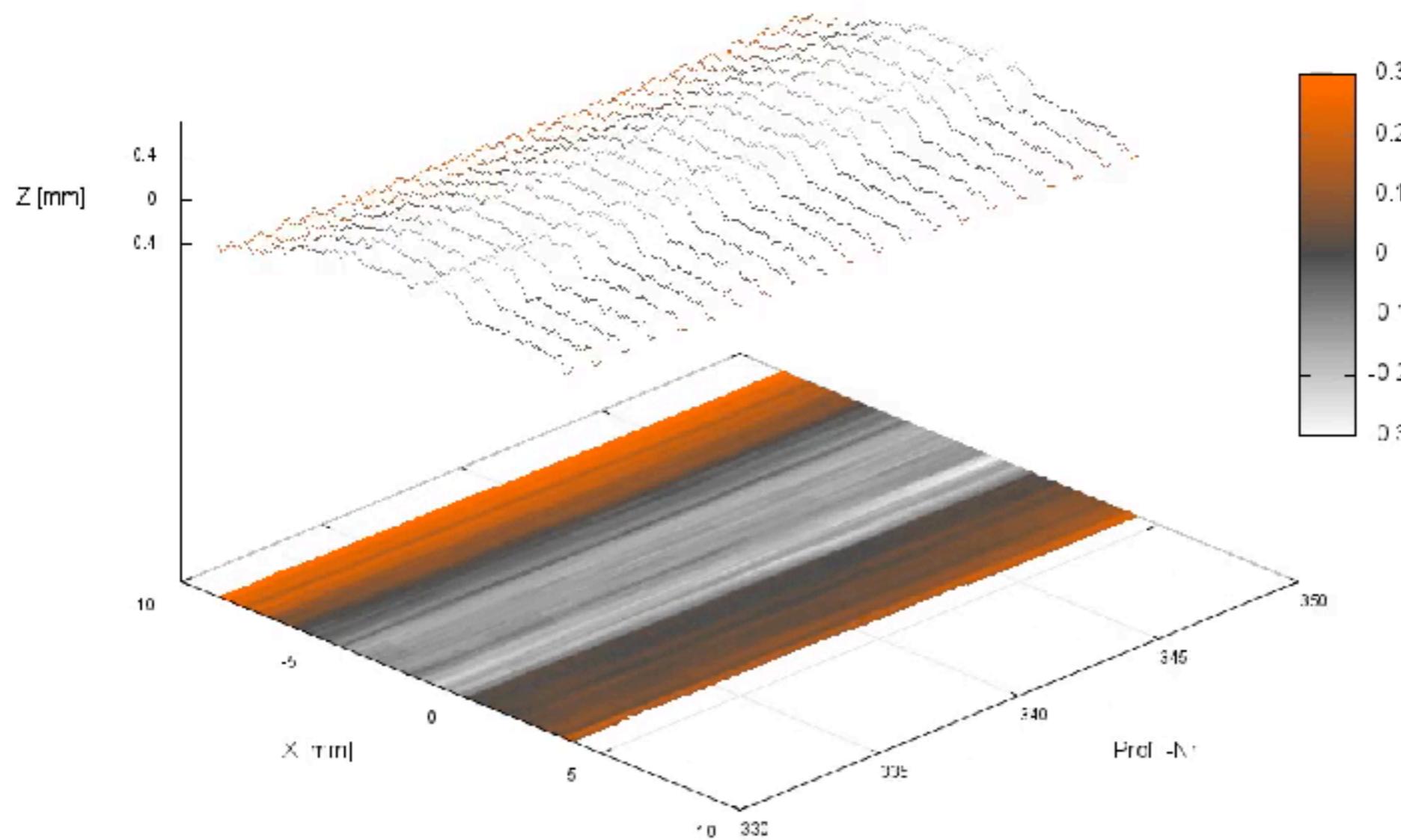
Online measurement of tapes



- Moving Tape
- Detection of:
 - top side and bottom side synchronized
 - ledge
 - width
 - thickness
 - area
 - „Ra“, „Rt“, „Rz“



Online-surface detection of Aramid-PEEK-tape



Facts F²-Compositor®

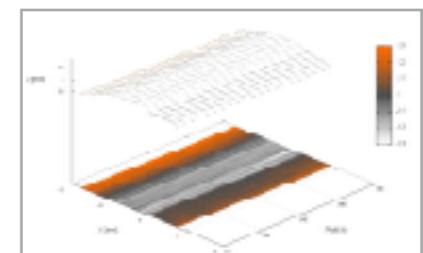
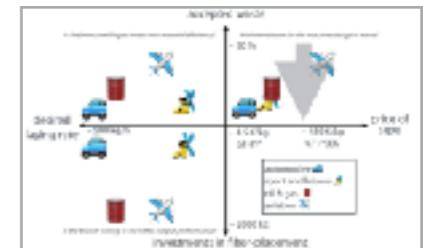
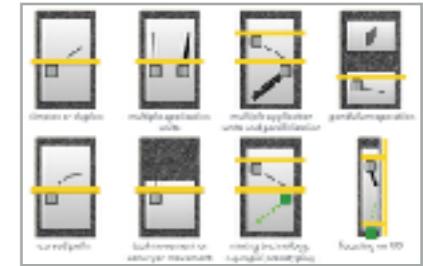
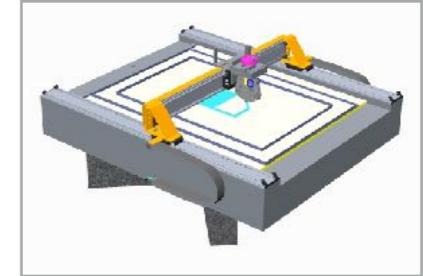
Investment range	85 k€ up to 1.5 m€ EXW, with documentation, without qualification effort*	less than competition (factor of 2-15)
Tape laying rate	5 kg/h up to 725 kg/h or more	difficult to compare
Tape width per application unit	5 mm up to 75 mm	unknown
Necessary power to produce a consolidated preform: Heating source + movement	1.5 kW/h up to 25 kW/h	less than competition (factor of 50-100)
Exposure time polymer above the melting point, to manufacture a consolidated preform for further IR-processing	0.025 s	less than competition (factor of 40.000)
Placement speed with precision	1-3 m/s	faster than competition (factor of 2-4)
Acceleration, deceleration with precision	20-50 m/s ²	faster than robots (factor of 10-25)
Workshop area to install a F ² -Compositor® with all infrastructure	10 m ² up to 38 m ²	less than competition (factor of 2-20)
Tested polymers with reinforcement	PP, PE, PA, PA derivates, PPA, PPS, PEEK, PEKK, "prepreg", ...	same as competition
Tested polymers without reinforcement	PP, PE, et. al.	unknown
Tested carrier substrate	None, polymer, polymer film, FRPC, sandwich, foam, steel, aluminium, wood, concrete	unknown
Waste	Waste intended to be none with miniaturization and design options of the F ² -Compositor®	difficult to compare
Design options	Coupling several small F ² -Compositors® to an assembly line, possible and reasonable to have no waste and a high laying rate Automatic spool change upon request F ² -Compositor® to F ² "out of plane"-Compositor	unknown

There are still challenges in the process chain

- Several partners are usually involved in a FRPC process chain
 - (Precursor)
 - Fiber
 - Polymer
 - Tape production
 - Preform production
 - Pre-product
 - Product in platform
 - OEM
- Interface losses are common
- Tape
 - Global established capacity is not huge
 - Technology of melt-impregnation has physical speed limits
 - Standardization is missing
 - Price of tape is not following the rule of raw material mixture + usual value adding
 - Price/mass is calculated for the 1st life-cycle for new equipment
- The global average OEM-competence in FRPC design with hybrid, anisotropic materials, including topology and structural optimization to offer clever assemblies is rather low
- URS is often not FRPC compliant

Summary long version

- ASH can deliver rapid fiber-placement solutions
 - We have know-how along the complete technology chain
 - We deliver customer or product specific machines
- F²-Compositor® is an adaptive machine, that can process multi-materials and multi cross-sections
- Unfortunately, every business case has to be considered individually, to balance technical and economic advantages
- Main motivator for industrial implementation is waste
- Our technology does not improve the quality of the semi-finished product
- Online quality inspection of the semi-finished product or the preform is possible
- Please challenge us to bring the composites to real production!



Thank you for your attention



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