Predictive Technical Cost Modelling of Fibre-Reinforced Composite Materials Enable Cost- and Weight-Efficient Composite Design

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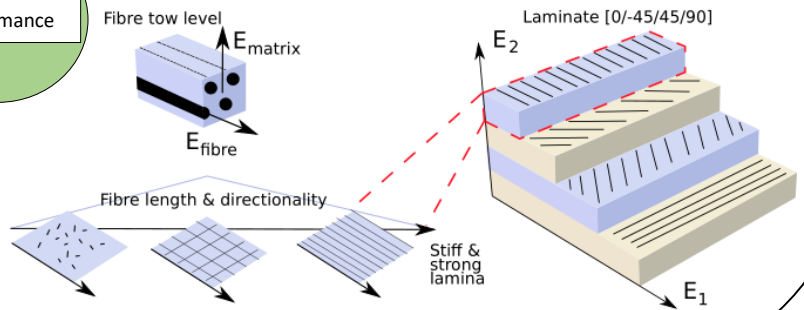
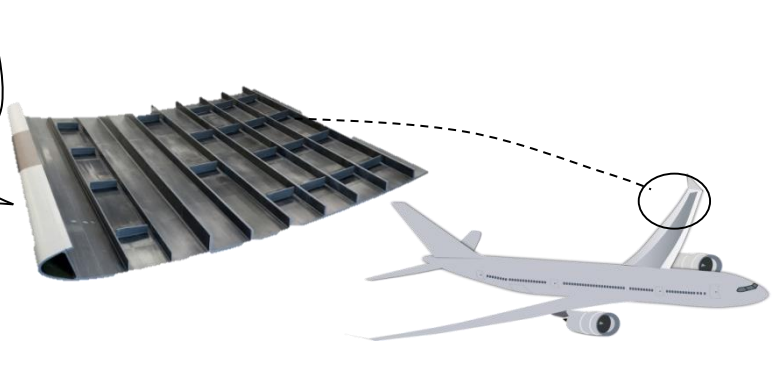
FRP- a lightweight and complex design

… reduces weight → E/ρ, σ/ ρ

Performance



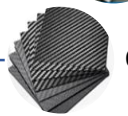


… but adds manufacturing complexity (variability!), time and cost!

Cost

Manuf & prod

Slow manufacture

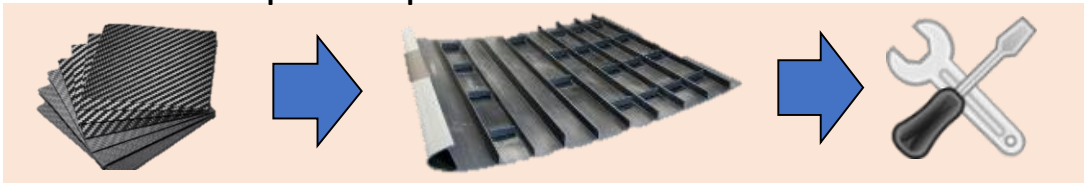


Costly fibres (carbon) $20 - 110\ {}^{€}/_{kg}$

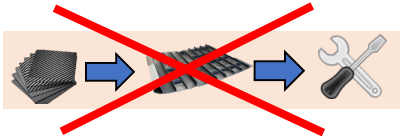
Production rates (2-150kg/h)

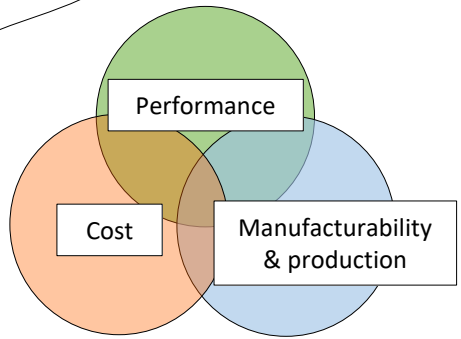
Early conceptual design controls structure and R&D cost

Linear development process



Early conceptual design controls structure and R&D cost



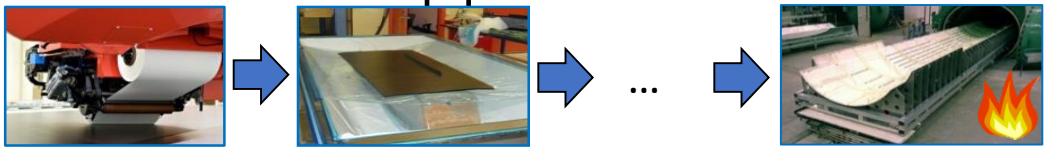


Physically sound simulations

Physically sound simulations
Manufacturing know-how

Cost predictions

Developed predictive technical cost model - a modular approach

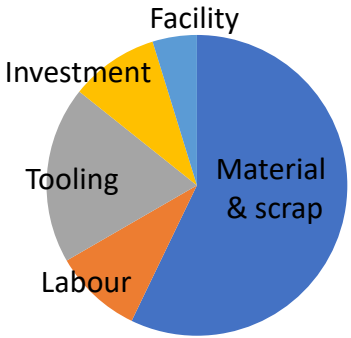


€/part?

Geometry Data from CAD

Developed toolbox

$$C_{tot} = Cmtrl + \sum_{i=step\ i}^{i_{end}} C_{i\,(A,C,n)}$$

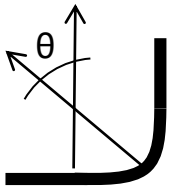


C_{mtrl}: Raw material cost

$$C_{mtrl} = C_{kg} w (1 + r_{scrap})$$

C: Part complexity

$$C = f(\theta)$$



A: Part size

$$t = \frac{L}{r}$$

$$r_i = r_0 C$$

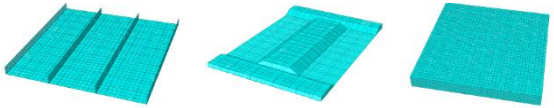
$$C_{tooling} = f(A)$$

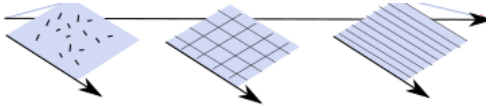
$$C_{equipment} = f(A)$$

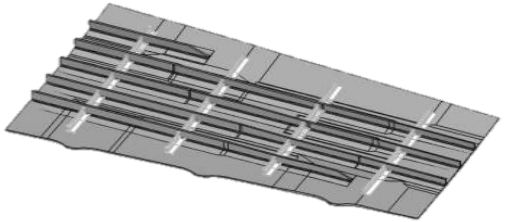
n: Annual manuf. volume

$$n^o\ machines = \frac{tn}{t_{tot}}$$

Case studies: - MD design potential with **increasing** degrees of freedom







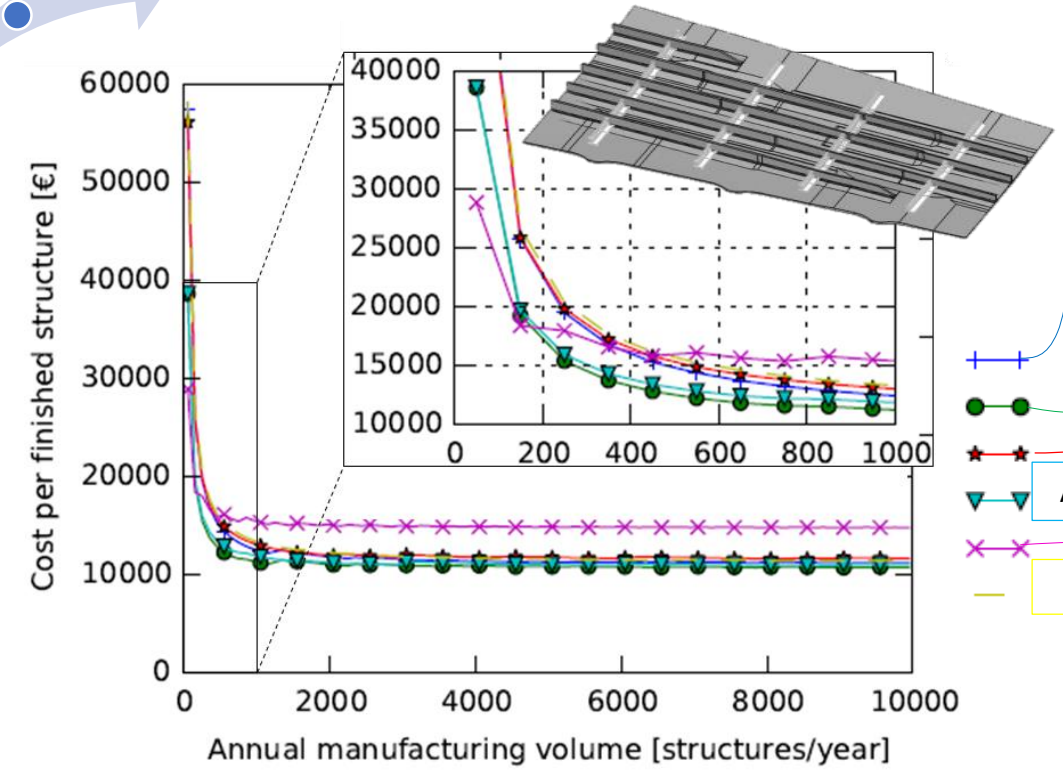
Choosing
– Geometry
– Material

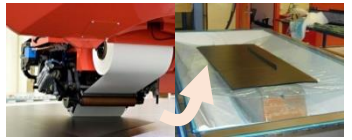
Introducing novel material systems

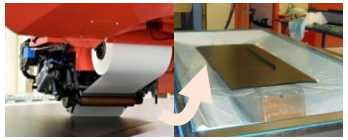
Choosing
– Manufacturing
– Integration level

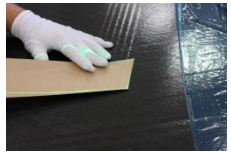
on a set geometry

Efficient manufacture today & future




ATL/HDF

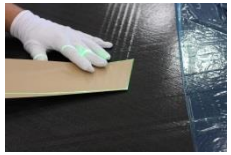

ATL/HDF


ML

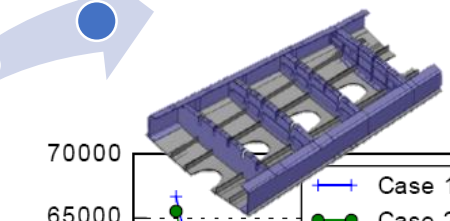
AFP/ML

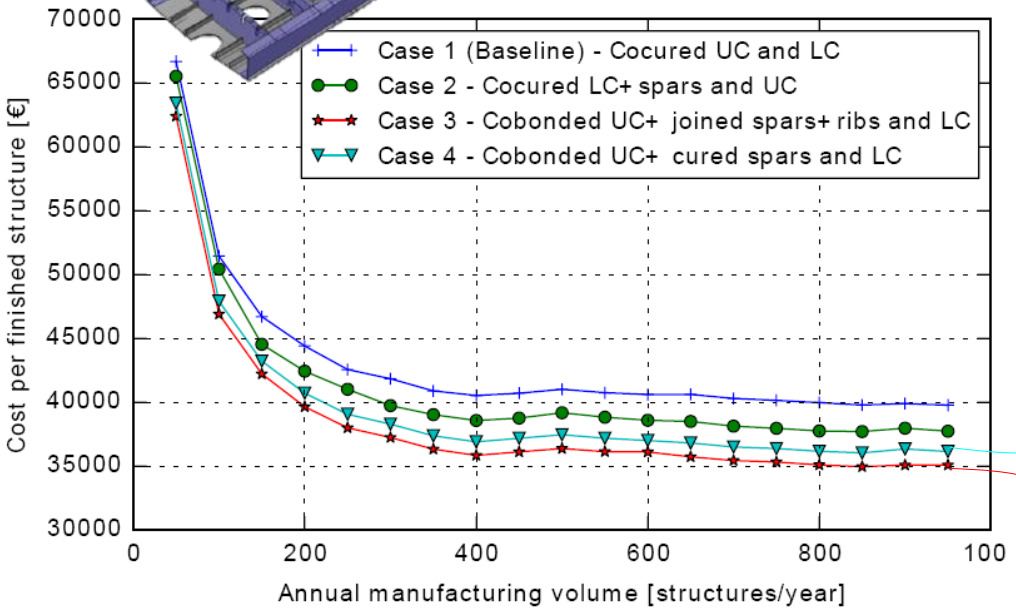
AFP/HDF


AFP


ML

Part integration reduces cost





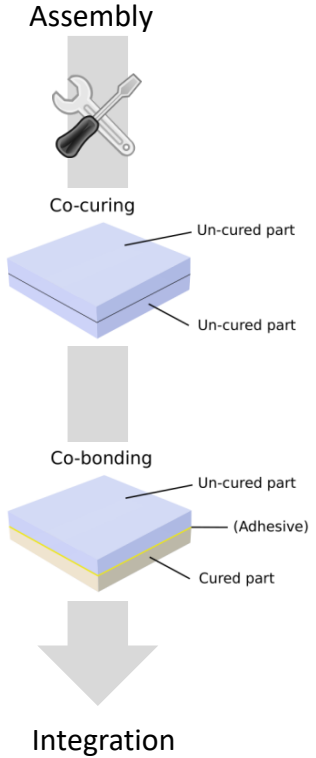
$\hat{C}_{tot}$

115%

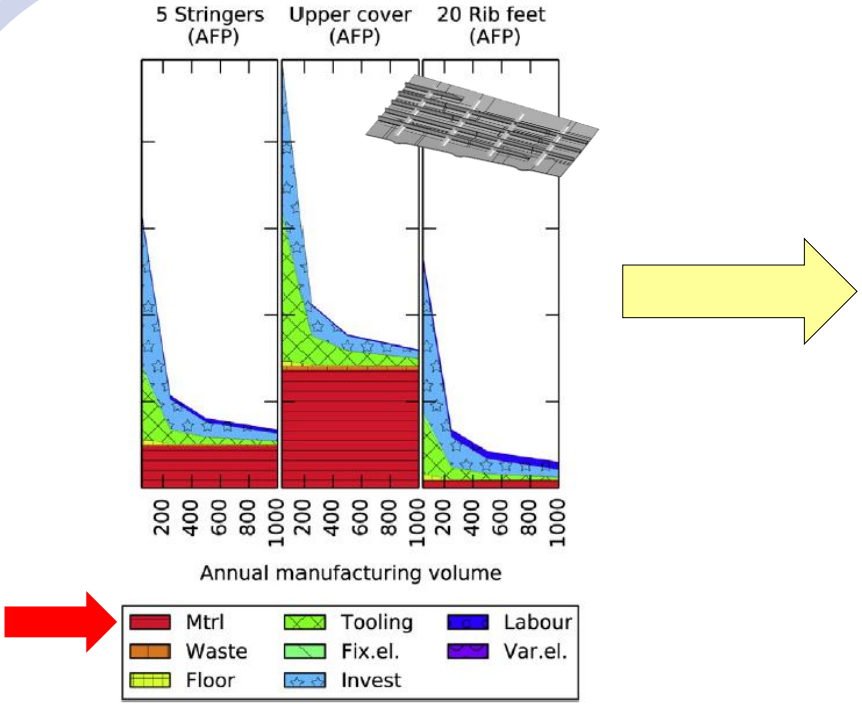
109%

102%

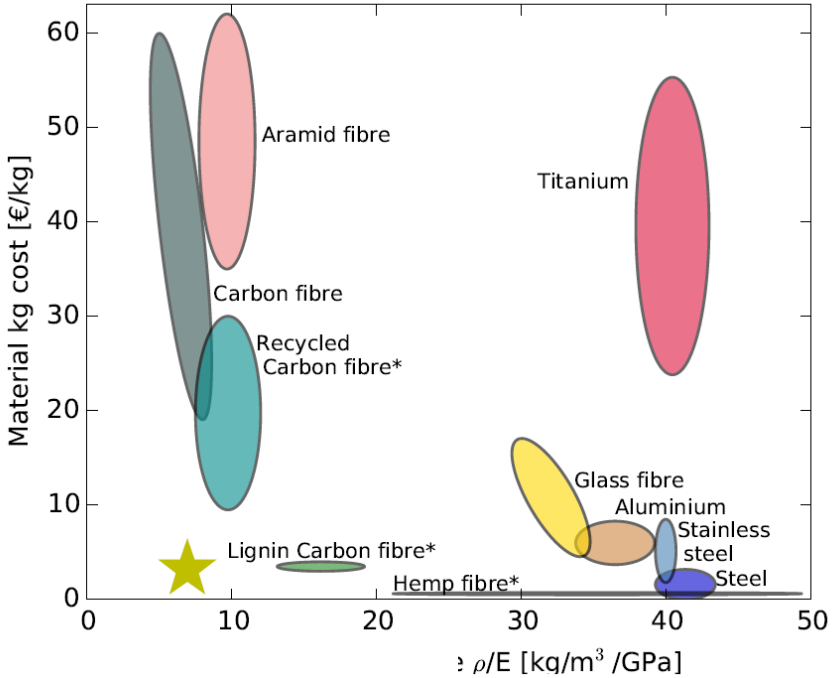
100%



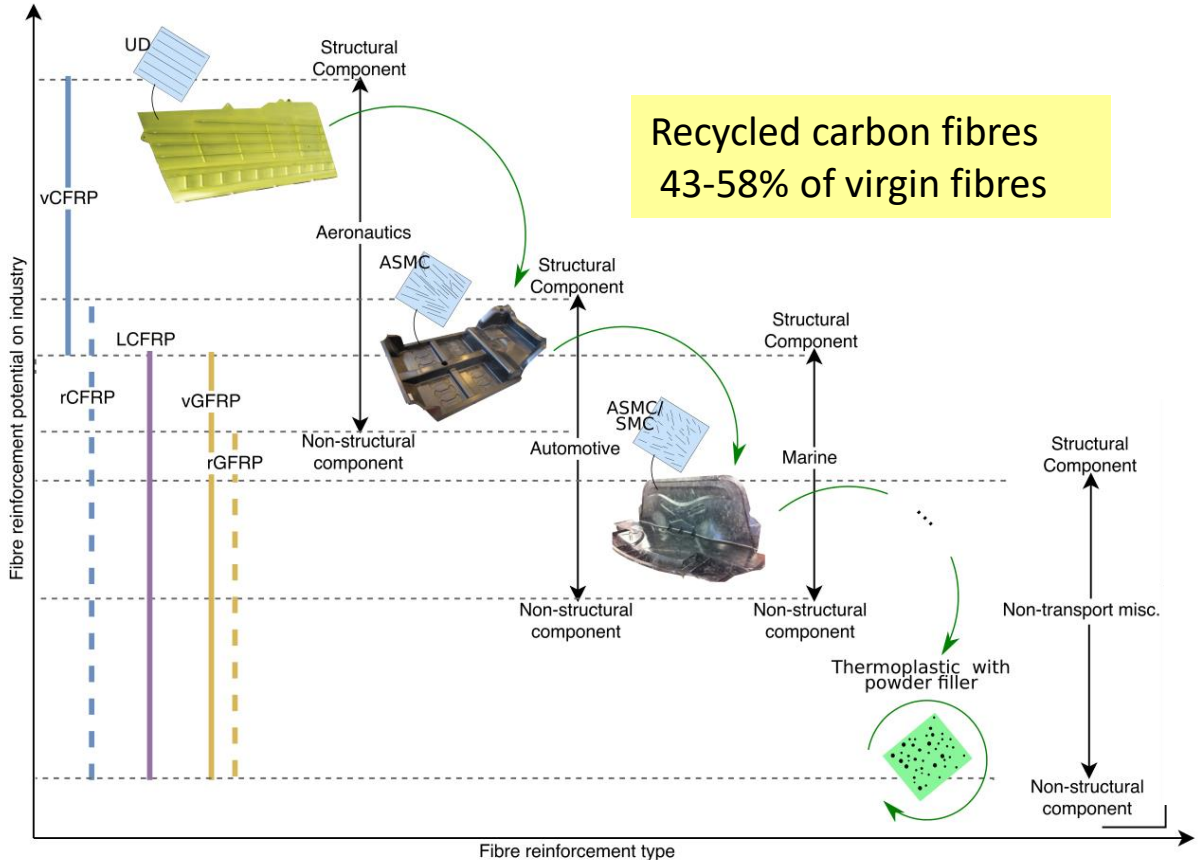
Automotive applications require higher production volumes & lower cost



Material selection is key!



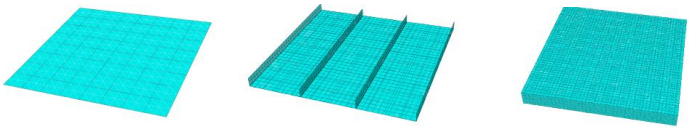
Reclaiming fibres reduces material cost



Recycled carbon fibres
43-58% of virgin fibres

Approaching Opt f(x) - the coupling

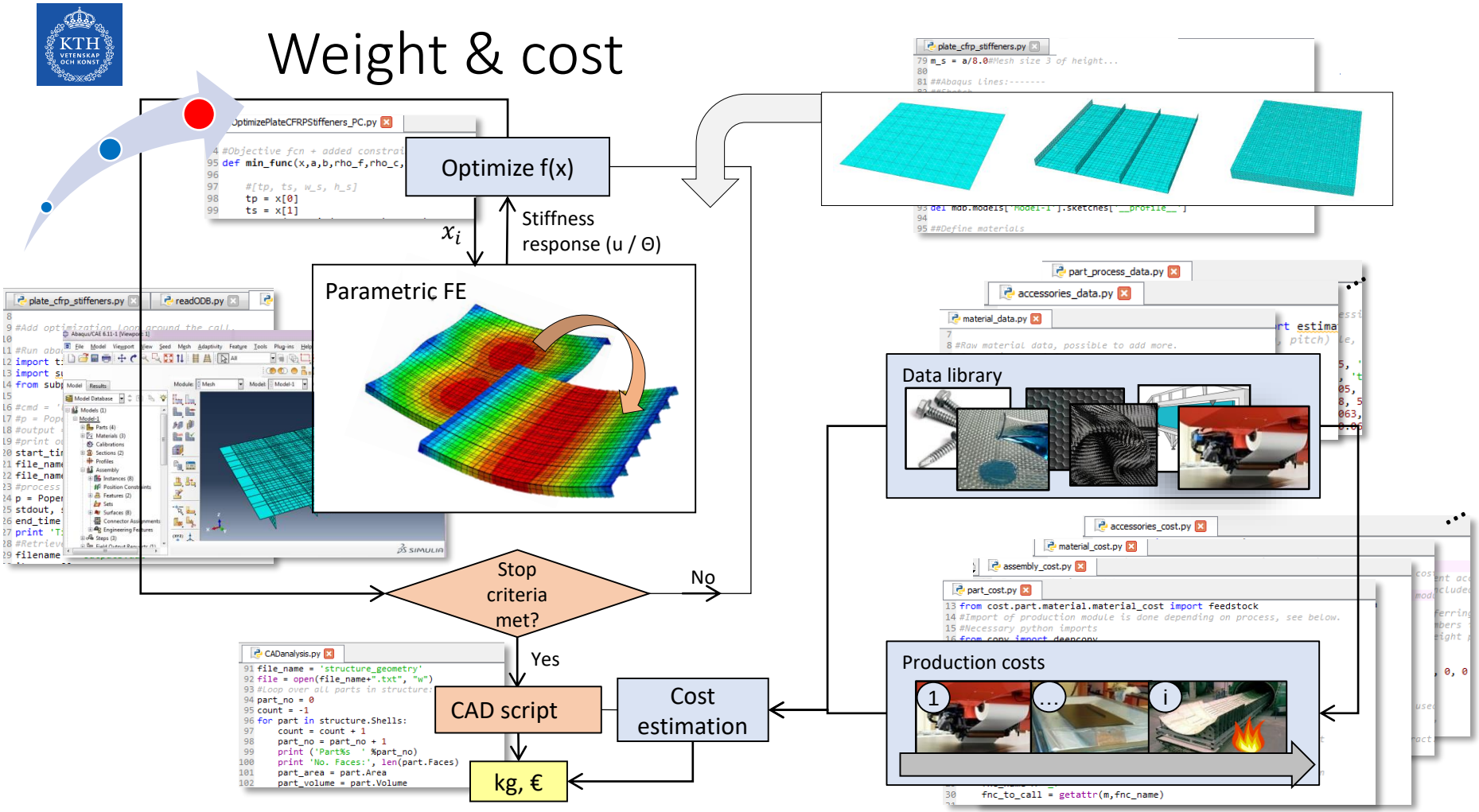
Parametric design ↔ material selection



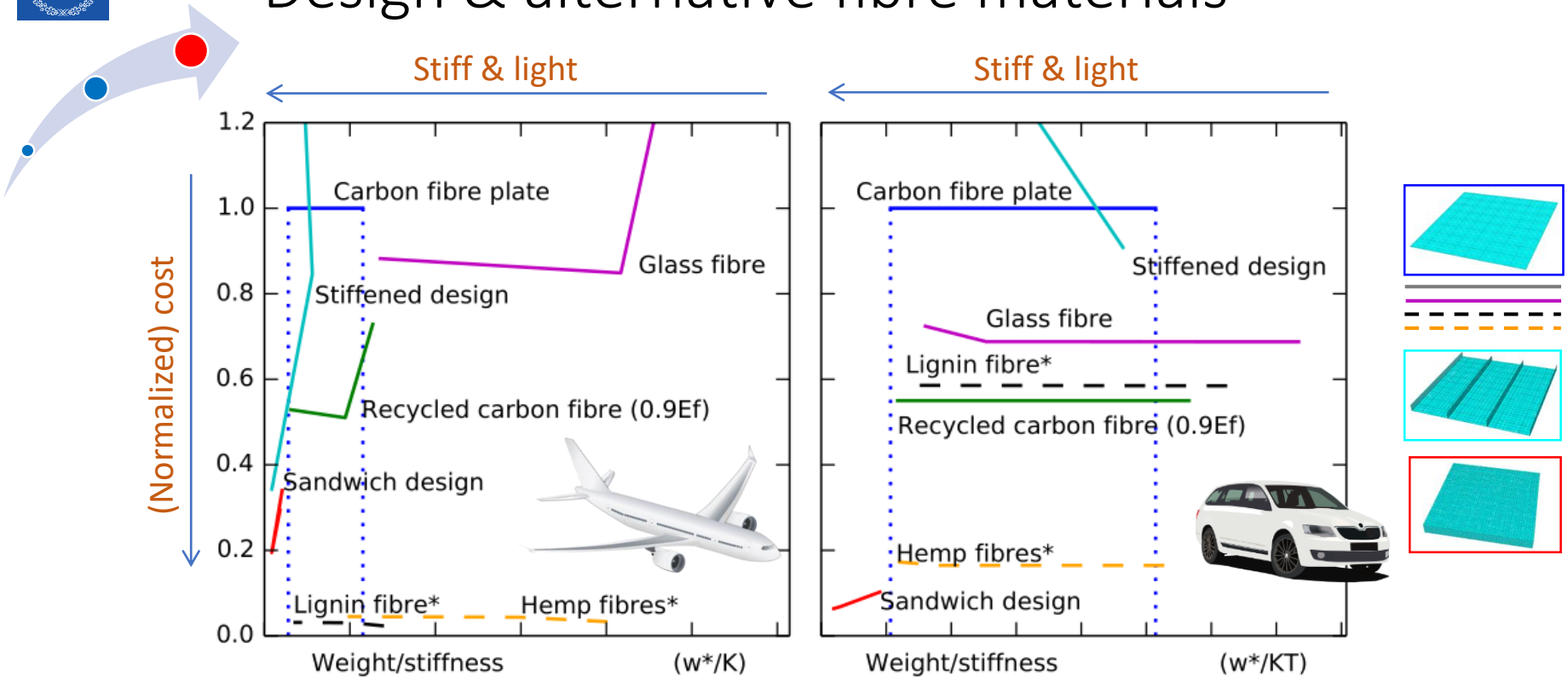
Optimize f(x)
s.t u / Θ

Allowed deflection, u [mm]	Minimal torsional stiffness $\hat{K_T}$ $[\frac{Nm}{\phi}]$
$0.1 - 0.01 - 0.001$	$1400 - 7000 - 14000$

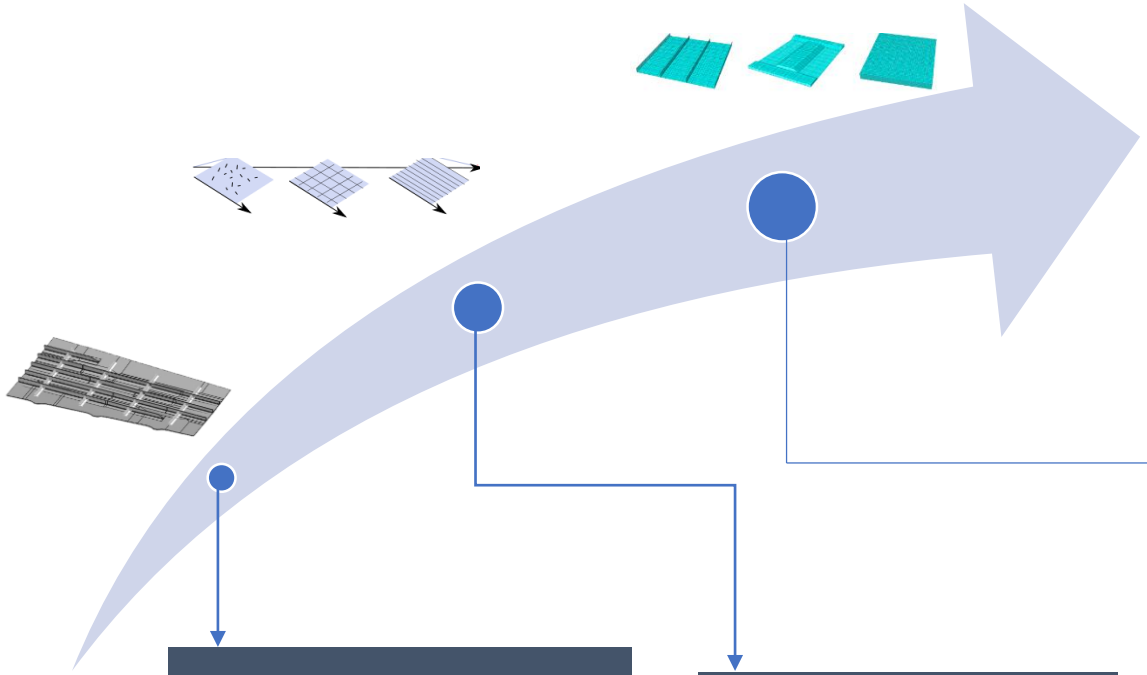
Weight & cost


OptimizePlateCFRPStiffeners_PC.py
Optimize f(x)
x_i
Stiffness
response (u / Θ)
plate_cfrp_stiffeners.py
readODB.py
Parametric FE
plate_cfrp_stiffeners.py
part_process_data.py
accessories_data.py
material_data.py
Data library
accessories_cost.py
material_cost.py
assembly_cost.py
part_cost.py
Production costs
Stop
criteria
met?
No
Yes
CADanalysis.py
CAD script
Cost
estimation
kg, €

Design & alternative fibre materials



Thoughts to bring with you!



Predictive technical cost modell methodology & application
↔
future strategic decisions on production & design of lightweight composite structures

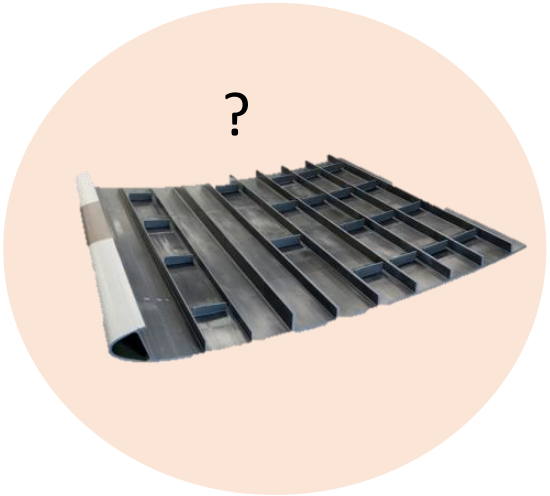
- Manufacture= f(smallest feature size, complexity, n)
- Part integration ↓€ ↑Risk!

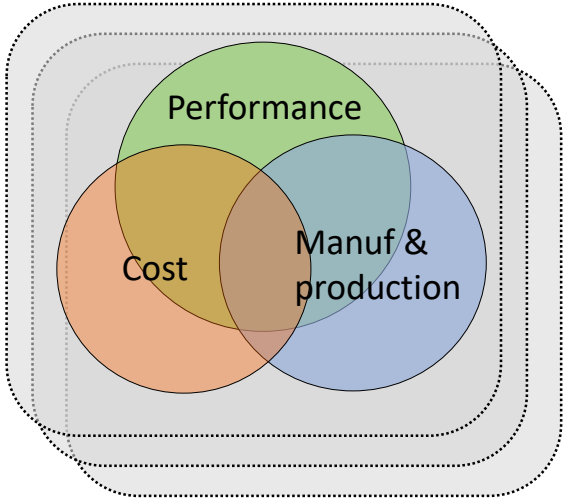
- Recycled CF ↓ 50% €!

- Sandwich design light and cost-effective!
- Automotive industry ← Natural fibres and recycled fibres

Outlook

- Any background (Environment, noise, safety etc)





- Any application (vehicle, construction, non-structural etc.)
- Any performance measure (σ, E, θ, ω etc.)
- Any production

LIFECYCLE

- Material
- Manufacturing & assembly
- Maintenance & repair
- Fuel
- Disposal