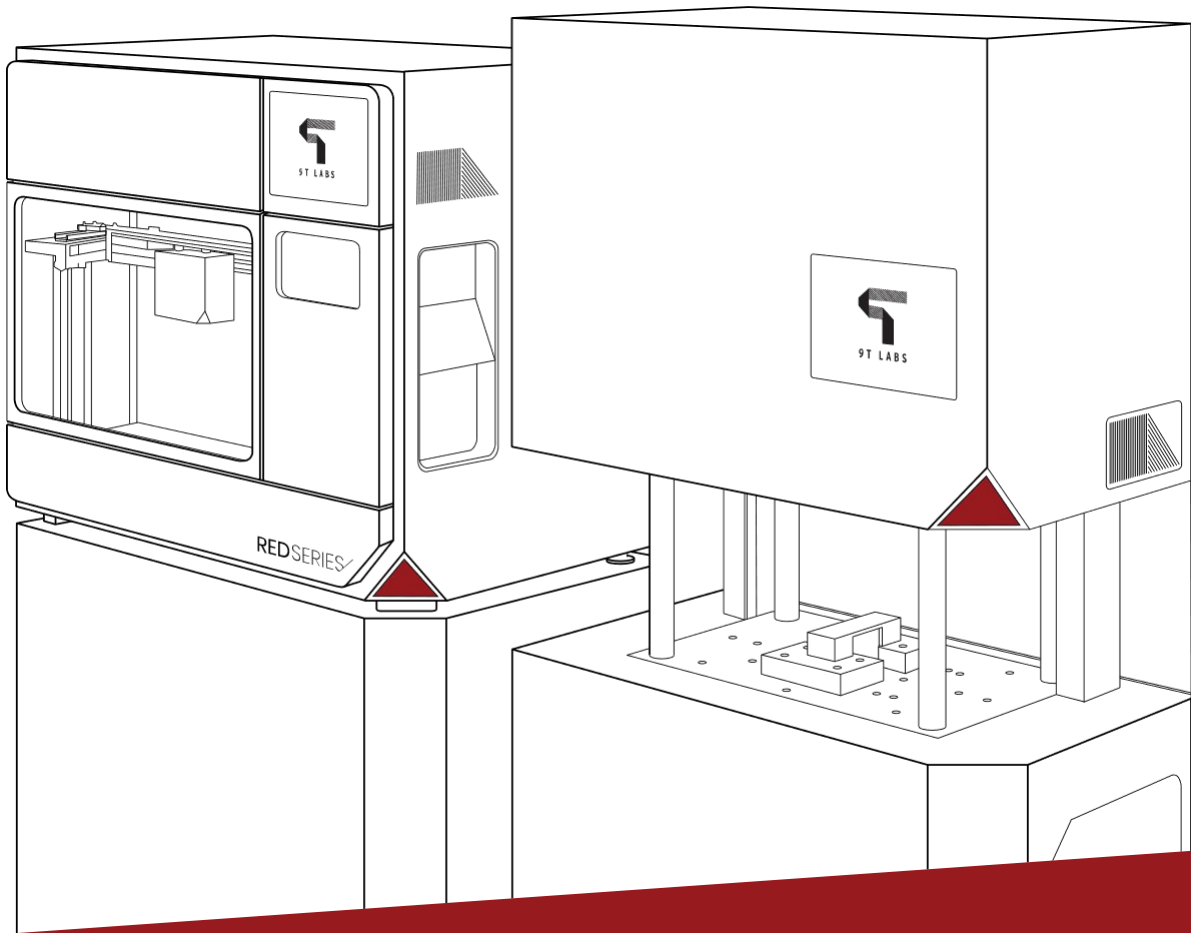
9T LABS

Red Series™

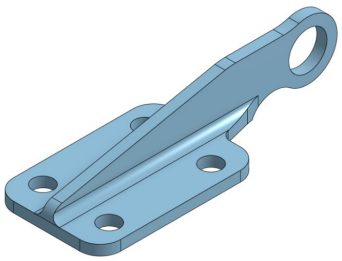
Feasibility Study

Aerospace Hinge



Objective & Technical Feasibility

Objective



Aerospace-grade steel hinge

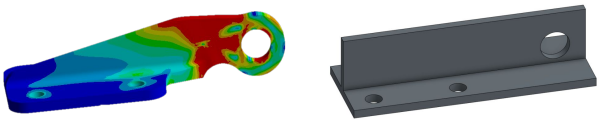
This *Preliminary Feasibility Study* shall give a first overview of the technical and economical feasibility of replacing the *aerospace-grade steel hinge* with its continuous carbon fiber reinforced PEKK counterpart, built with Red Series™.

To achieve this objective, the following topics have been prepared:

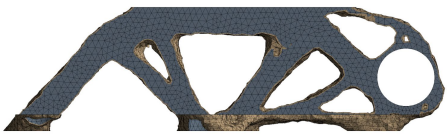
- Topology optimization & Redesign
- Multi-body strategy
- Reinforcement strategy
- Technical information & Potential weight reduction
- Cost analysis

Topology optimization & Redesign

Based on the given design space, the given boundary and loading conditions, a topology optimization with Ansys is performed to optimize the material layout and to determine the main load paths within the part.



Loading conditions | Design space



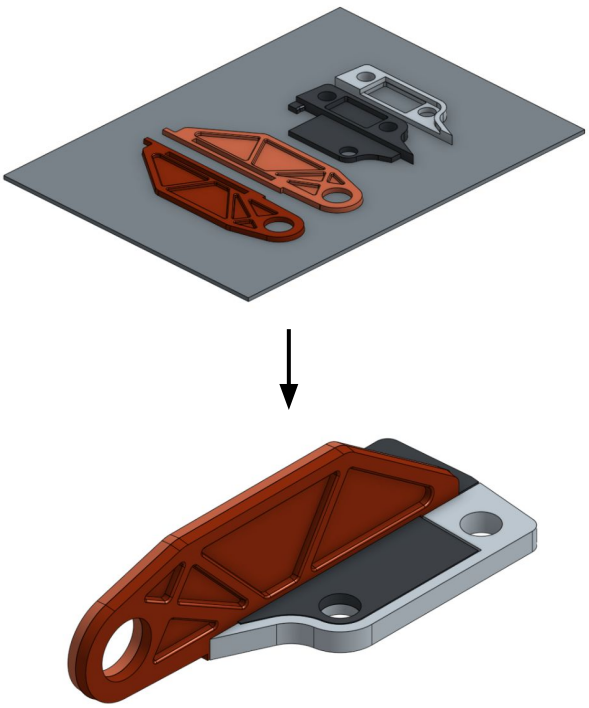
Topology optimization

Optimized redesign

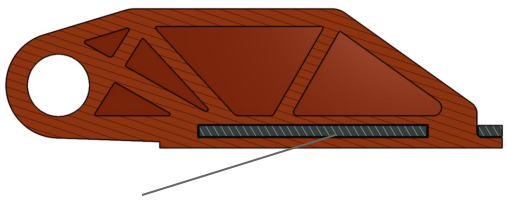
Then, the original aerospace-grade steel hinge is redesigned and a new CAD-model is created based on the results of the optimization process.

Multi-body strategy

To optimize fiber placement, separate sub-parts can be printed individually, assembled and then consolidated together during the fusion process.



This ensures that all force application points and interfaces can be reinforced according to the boundary and loading conditions and sub-parts can be interlocked mechanically.

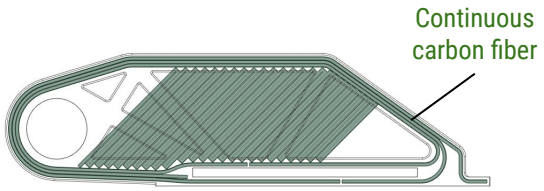


Interlocking of sub-parts to create a mechanical connection between base and vertical plates

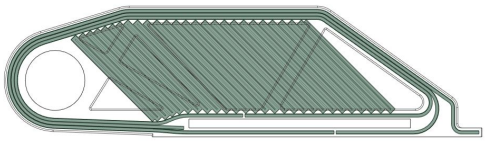
Reinforcement strategy

Vertical plate 1&2

Multiple fiber layups can be designed and combined to a final stackup to optimize fiber placement, according to the loading conditions.

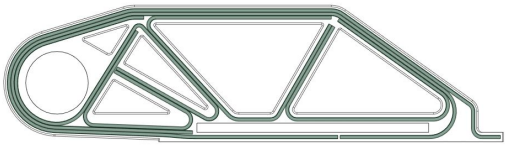


Layup 1



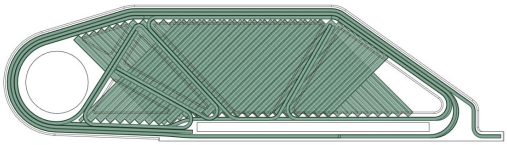
Layup 2

Layup 1 and *Layup 2* form a ±45° shear webb to enhance torsional stiffness.



Layup 3

Layup 3 reinforces the ribs of the vertical plates, which follow along the main load paths.

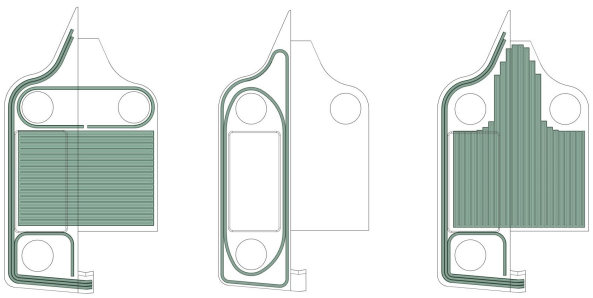


Final stackup

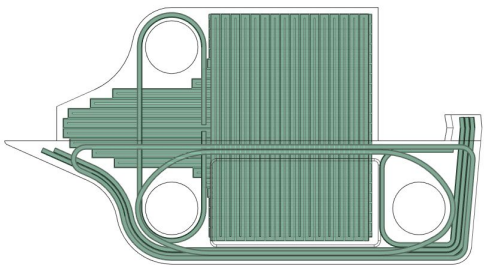
The *Final stackup* consists of an optimized combination and vertical distribution of *Layups 1-3*.

Technical Feasibility

Reinforcement strategy
Base plate 1

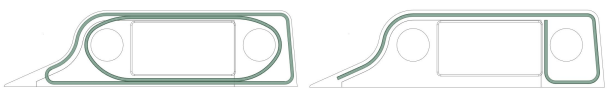


Layup 1 | Layup 2 | Layup 3

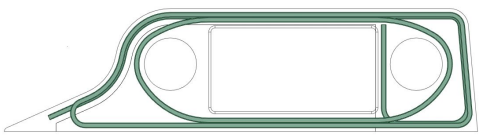


Final stackup

Reinforcement strategy
Base plate 2

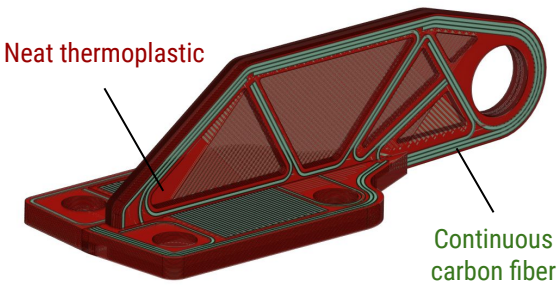


Layup 1 | Layup 2



Final stackup

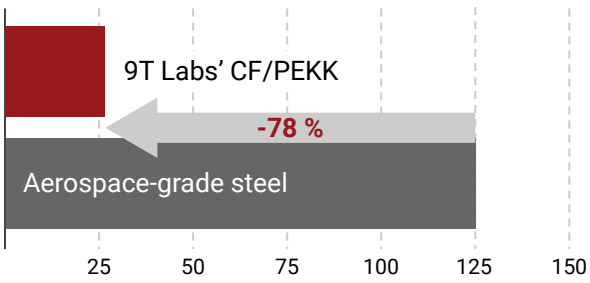
Reinforcement strategy
Final assembly



Technical information

Material	*CF/PEKK- & PEKK-filament*
Global V_f	*39 %*
CF/PEKK (60% V_f)	*65 %*
neat PEKK	*35 %*
Part volume	*18.3 cm^3*
Part weight	*27 g*

Potential weight reduction
[g/part]

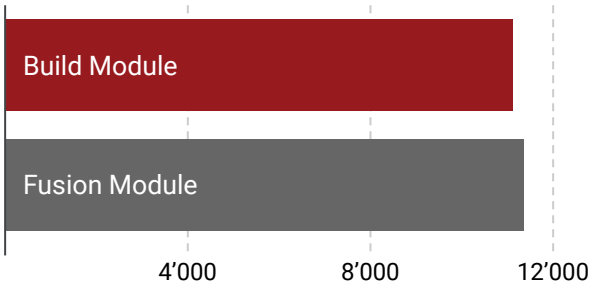


Cost Analysis

Red Series™ production start: 2023

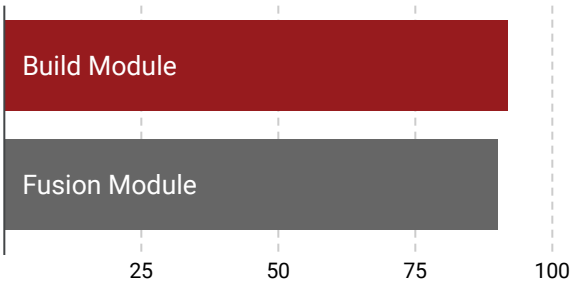
Production capacity

[Assemblies/year]



Utilization Rate

[%]



Assumption: Multiple applications are manufactured with Red Series machines, reaching a utilisation of > 90%.

Production costs

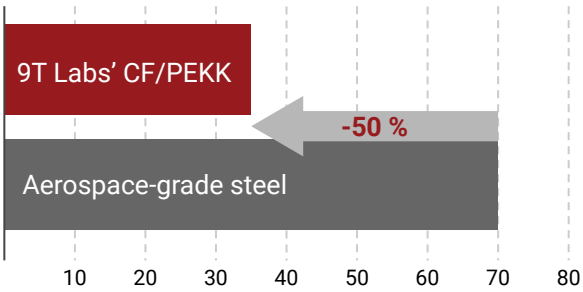
Annual leasing fee	*28k EUR/Module*
Overhead	*30 %*
Material costs	*CF/PEKK: 400 EUR/kg* *PEKK: 250 EUR/kg*
Labour costs	*28 EUR/h*
Production costs	***19 EUR/part***

Tooling costs

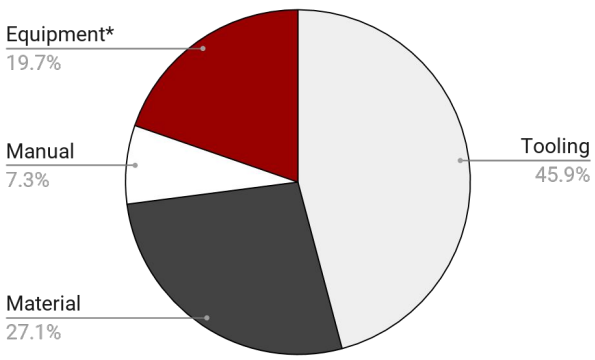
Acquisition costs	12'000 EUR
Production volume	150 parts/year
Planned production years	*5 years*
Tooling costs	***16 EUR/part***

Cost comparison

[EUR/part]



Part production cost driver



* Equipment costs include software licences, service, maintenance and overhead costs.