



Lightweight, sustainable, safe

## TRANSPORTING LOADS EASILY, SAFELY AND RELIABLY WITH THE LIGHTWEIGHT-CARGO BIKE »L-LBF«

Nowadays, mobility in cities is undergoing a visible change. Cargo bikes are becoming a key alternative to cars. They are not only flexible and fast but moreover environmentally- and climate-friendly. Young families, craftspeople and delivery services are using cargo bikes and the demand thereof is skyrocketing. In 2020 for the first time more than 100.000 cargo bikes were sold in Germany of which 78.000 had electric drive [\*]. There are many good reasons to expect a significant global rise in sale for these bikes within the next few years. One important reason is the global climate. The negotiated Paris Agreement of 2015 set the limit of global warming to 2 °C. This necessitates an extreme reduction of the global greenhouse gas emission. A change in mobility from cars with combustion engine to electrical driven micro-mobility is one step in the right direction.

Therefore, Fraunhofer LBF develops sustainable, comfortable, lightweight solutions for the next generation of cargo bikes. As the starting point for these advancements, commercial cargo bikes are used.

### Lightweight frames and wheels

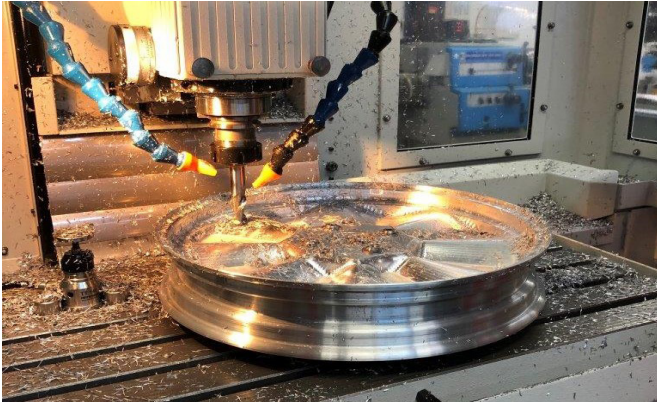
To demonstrate the potential for lightweight construction in a new design, the front end of the tricycle was chosen. Starting by compiling the initial data on the weight and geometry of

the front end's individual components, the groundwork for this redesign was done. Measurements were then carried out during driving operation. The frame was then redesigned by creating CAD-models and thereof deriving FE-models. The result is summarized in the following table.

Destination	Weight	Savings	
Tricycle front part	105,9 kg	-39 %	
Lightweight front part	64,7 kg		
Destination	Material	Weight	Savings
Original frame	Al	47,8 kg	-48 %
Light weight frame	Al	24,7 kg	
Original axis	Steel	8,4 kg	-58 %
Lightweight axis	Al	3,5 kg	
Coupling elements	Steel	9,7 kg	-73 %
Lightweight coupling elements	Al	2,6 kg	
Original wheel rim	Steel	5,92 kg	-61 %
Corrugated rim	Al	2,3 kg	
Lightweight spoke rim	Al	1,9 kg	-67 %
Lightweight hole pattern rim	Al	2,2 kg	-62 %

Within a short period of time, Fraunhofer LBF has succeeded in manufacturing a frame that is lighter by 39 percent, while maintaining the same loading capacity. In addition to the frame, which central element is now a tube fabricated out of

an aluminum alloy (AlMgSi1), in which the new caseless battery system is easily embedded, new rims were also designed and manufactured. The rims come in three different designs: perforated, spoke, and the wave web design. They are all made of aluminum alloy, resulting in further weight reduction of at least 60 percent compared to the original steel rims.



Design and manufacturing of new rims at Fraunhofer LBF

## Transport boxes

Compared to standard transport boxes made of wood or aluminum, boxes were constructed at the Fraunhofer LBF whose inlets reflect the variety of possibilities for material combinations depending on customer requirements.

- **Ultralight transport box:** CFRP in combination with honeycomb or crash structures, manufactured by using the additive manufacturing process. Used for safely transporting fragile goods.
- **Bio-transport box:** 100 percent natural materials in a sandwich structure, e.g., flax fabric with granulated cork or flax meadow fibers with bark mulch. Biopolymers such as polylactide are used as binding agents. Suitable for transporting hot meals, due to the good thermal insulation properties of these biomaterials.
- **Sustainability transport box:** 100 percent recycled materials are used for the construction of these boxes. Sandwich systems can be constructed from organic sheet (e.g. flax fiber reinforced with PP from drinking bottles) as the top layer and PU core material from used mattresses. Alternatively, old textiles can also be used.

## More information

[www.lbf.fraunhofer.de/de/projekte/leichtbau-lastenfahrrad.html](http://www.lbf.fraunhofer.de/de/projekte/leichtbau-lastenfahrrad.html)

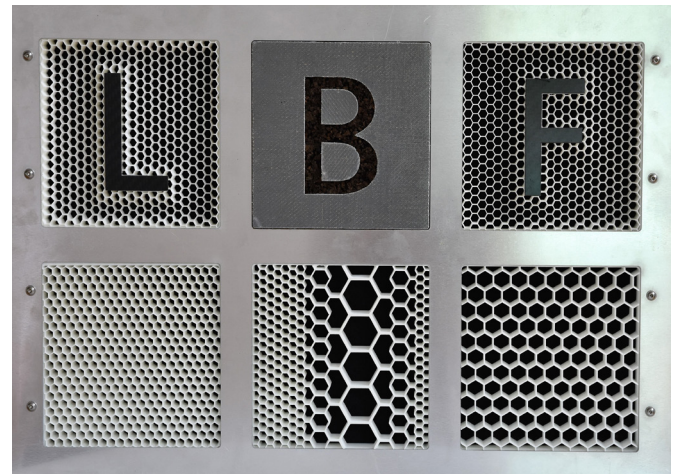
\*Source: Zweirad-Industrie-Verband, Marktpräsentation 2021

## Outlook

In addition, the Fraunhofer LBF is working to develop

- integrable and cost-effective **sensor modules** that monitor the position and mass of the payload during the ride
- **scratch protection** coatings for rain protection systems for cycles and displays
- **Battery systems**, which are integrated into the frame structure, making in a way them both theft- and weatherproof.

In cooperation with the manufacturing industry, these ideas for modification are being further developed based on the identified need.



Ultralight plastic transport box: Honeycomb structures in combination with CFRP

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