

KMF-Regio, A Generic Modular Designed Regional Train Model

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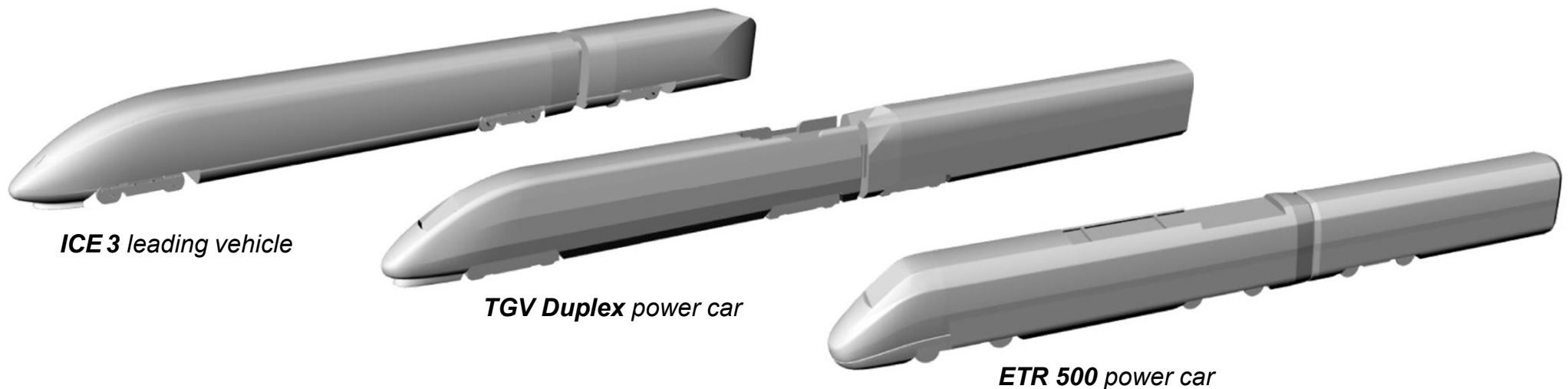


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Benchmark vehicles in HST Testing



- In Hight-Speed Train wind-tunnel testing, three designs are available which are open to the public (*EN-14067-6*)
- They are used for certification of new wind tunnel and to proof the validity of the experimental setup by comparing on-site results to given benchmark data
- In addition, these geometries are used for CFD simulations when an open design is needed, for example for publication (especially ICE 3)



A regional train is somehow different

- **HST:** 250 – 400 km/h
streamlined head
smooth roof
- **Regional train:** 100 – 160 km/h (faster in the near future)
blunt head
roof equipped with boxes



Regional train leaving „Gare de Champagne-Ardenne TGV“ near Reims

There is no
Benchmark vehicle
for a regional train
comparable to
high-speed train
testing



Generic vehicles in automotive testing



old times

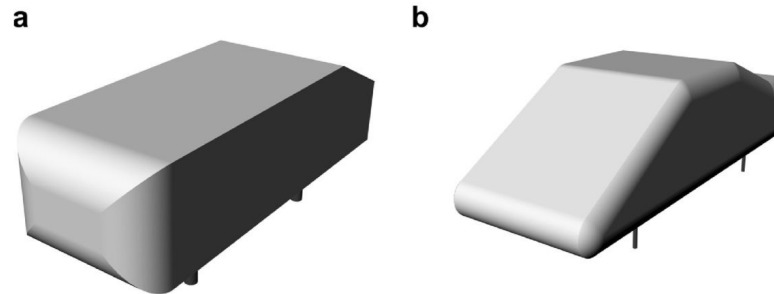


Fig. 1. Two generic automotive bluff bodies with a different level of geometrical complexity: (a) Ahmed body, (b) SAE reference geometry.

There is no publicly available, generic geometry for a regional train comparable to automotive industry

nowadays

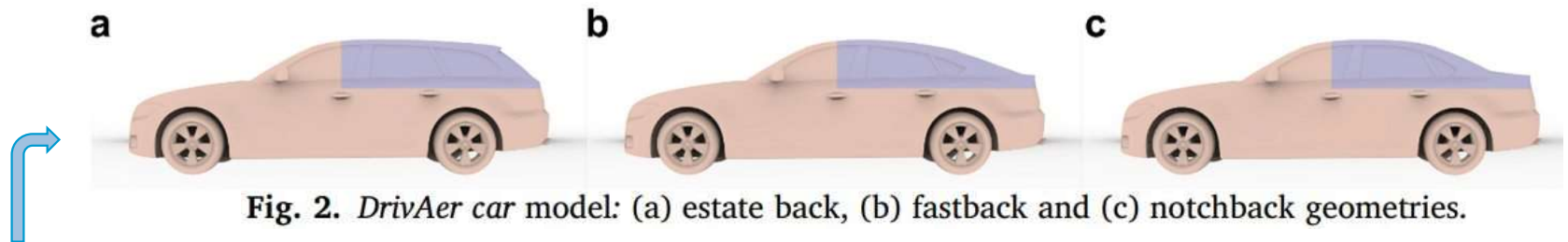


Fig. 2. DrivAer car model: (a) estate back, (b) fastback and (c) notchback geometries.

modular design allowing for three different variants of the rear of the car

Figures copyright: Peng Qin^{a,*}, Alessio Ricci^{a,b,c}, Bert Blocken^{c,d}

CFD simulation of aerodynamic forces on the DrivAer car model: Impact of computational parameters

[Journal of Wind Engineering & Industrial Aerodynamics 248 \(2024\) 105711](#)

Concept for a generic regional train



- It is similar to real trains currently in operation (with respect to shape, size, attached components and length)
- A train of arbitrary length can be put together
- Components can be attached/removed/exchanged...

In summary: It is of modular design

Dimensions in full-scale

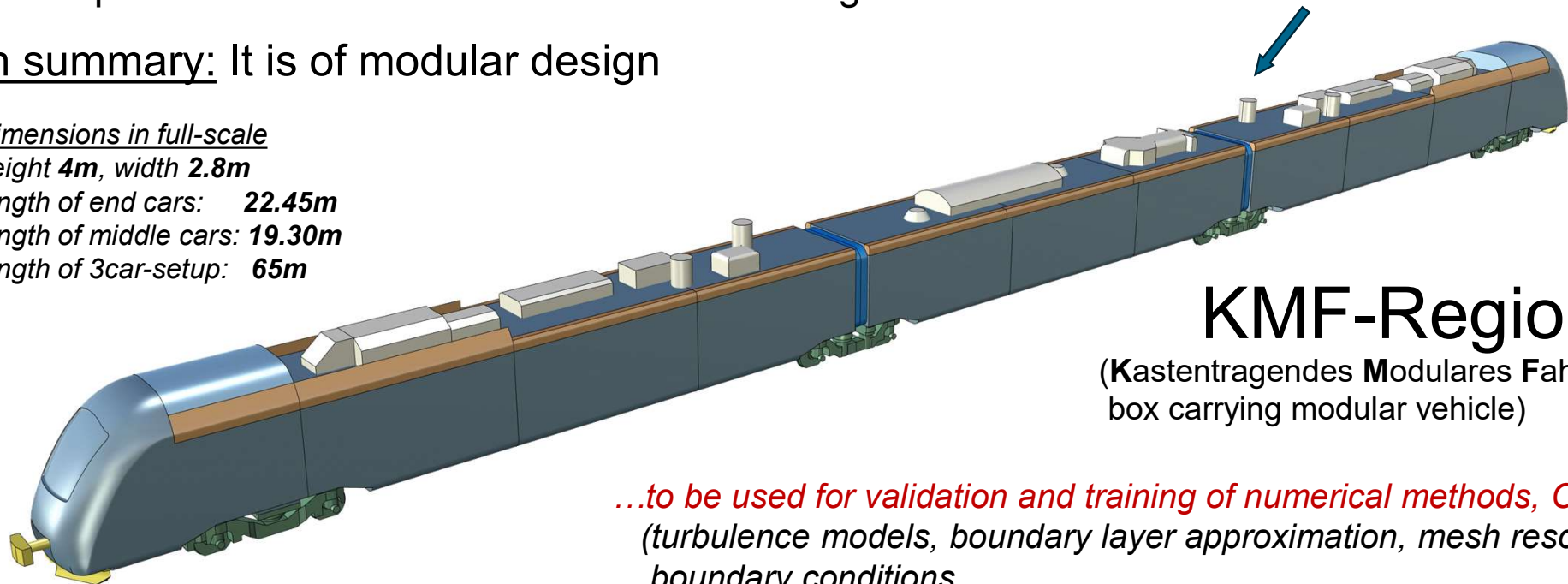
height **4m**, width **2.8m**

length of end cars: **22.45m**

length of middle cars: **19.30m**

length of 3car-setup: **65m**

*Generic roof setup not yet defined
(just for illustration purposes here
to show a somehow realistic design)*



KMF-Regio

(Kastenträgendes **M**odulares **F**ahrzeug:
box carrying modular vehicle)

*...to be used for validation and training of numerical methods, CFD:
(turbulence models, boundary layer approximation, mesh resolution,
boundary conditions...
in comparison to experimental results)*

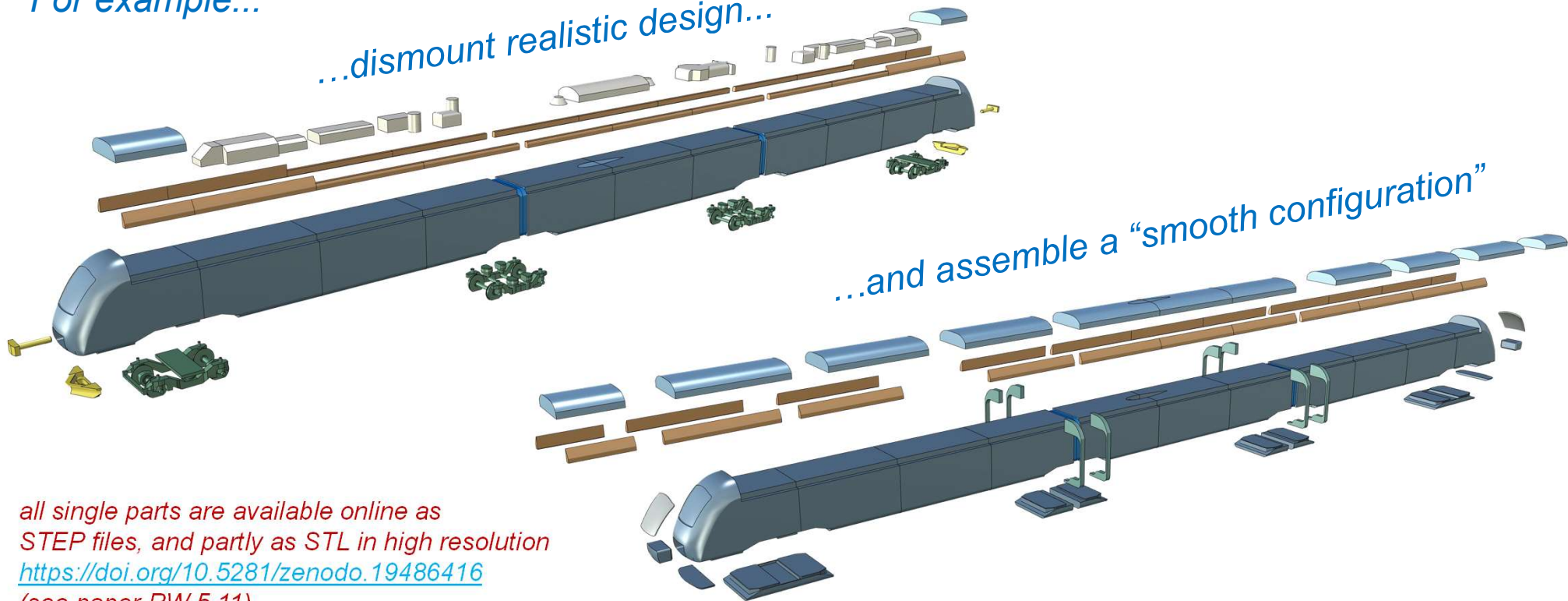
Change of configurations („LEGO-Box“ concept)

For example...

...dismount realistic design...

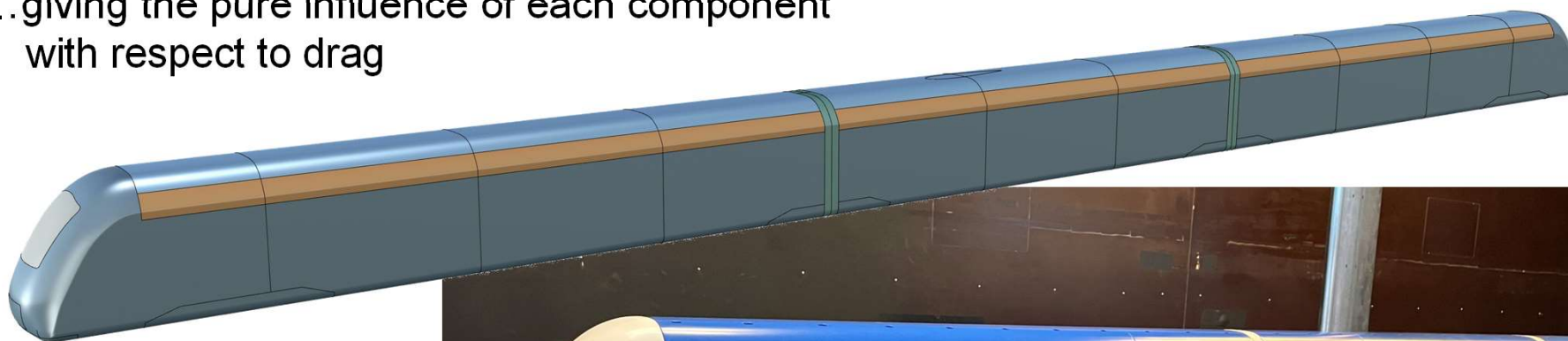
...and assemble a “smooth configuration”

*all single parts are available online as
STEP files, and partly as STL in high resolution
<https://doi.org/10.5281/zenodo.19486416>
(see paper RW.5.11)*



Smooth configuration c01 of KMF-Regio

- With respect to drag prediction, this should be the configuration with the lowest possible drag value (for the given length)
- External parts (roof boxes, bogies, open inter-car gaps, coupler, snow-plow...) can be added successively...
- ...giving the pure influence of each component with respect to drag



drag measurements have been performed in the Göttingen SWG wind tunnel using a moving belt

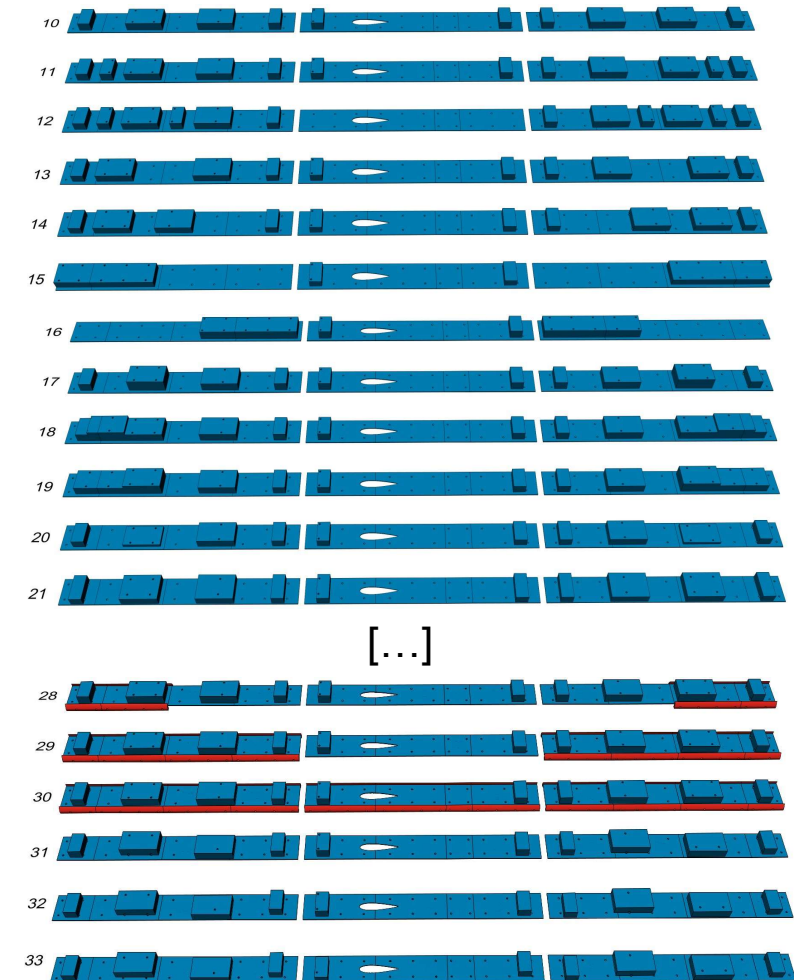


wind tunnel model, scale 1:20, on moving belt

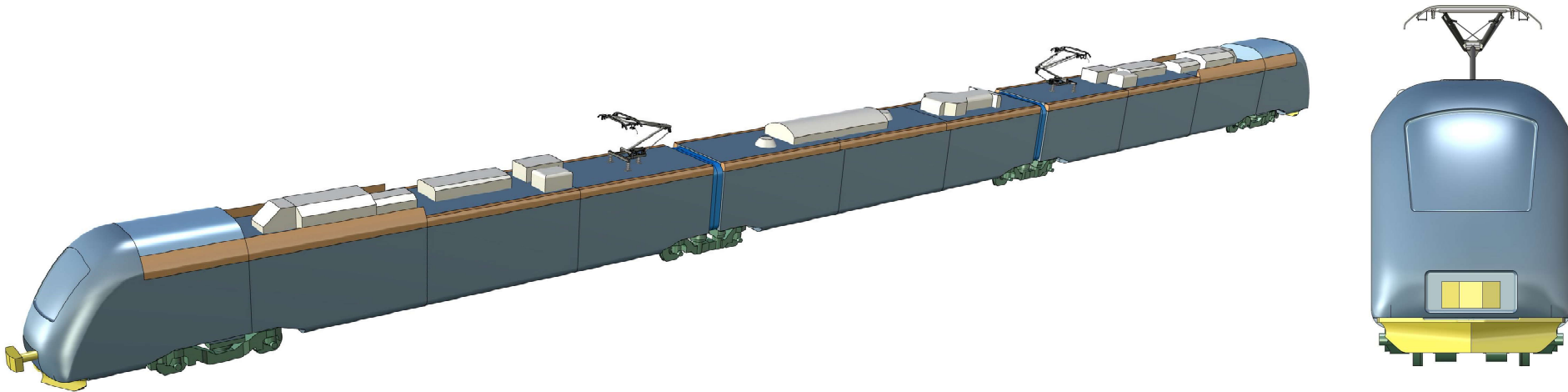
Drag measurements for a multitude of roof setups



3D-printed roof boxes were attached to the **smooth configuration** to get the clean influence of box-arrangement on drag (without additional drag caused by bogies etc.)



Drag contribution of bogies, coupler, pantograph etc.

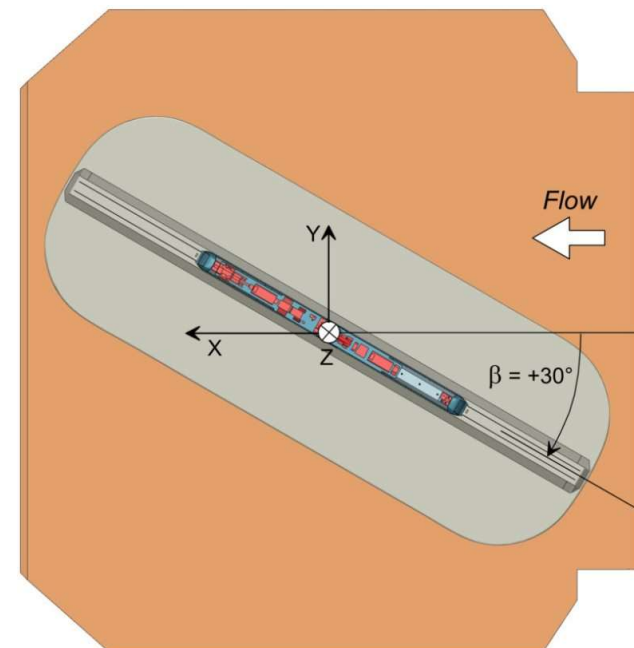


- will be the subject of an **upcoming measurement campaign** (hopefully end of 2026)
- also the influence of the pantograph can be investigated
- all experimental results will be provided for public access as a database

<https://doi.org/10.5281/zenodo.19486416>

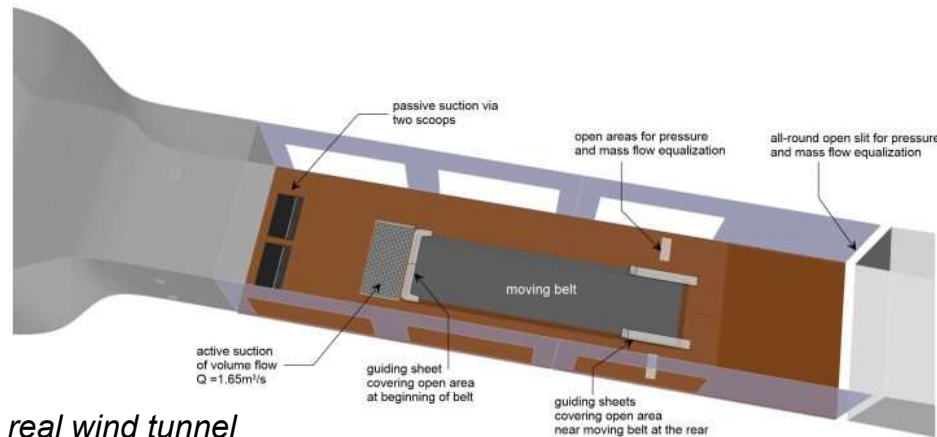
*Ultimately, a generic, realistic-looking roof-box setup should be defined, allowing the model to be used in the same way as the current HST benchmark models from the EN (but representing a regional train)
...for homologation testing (i.e. crosswind assessment)*

Wind-tunnel model for crosswind assessment

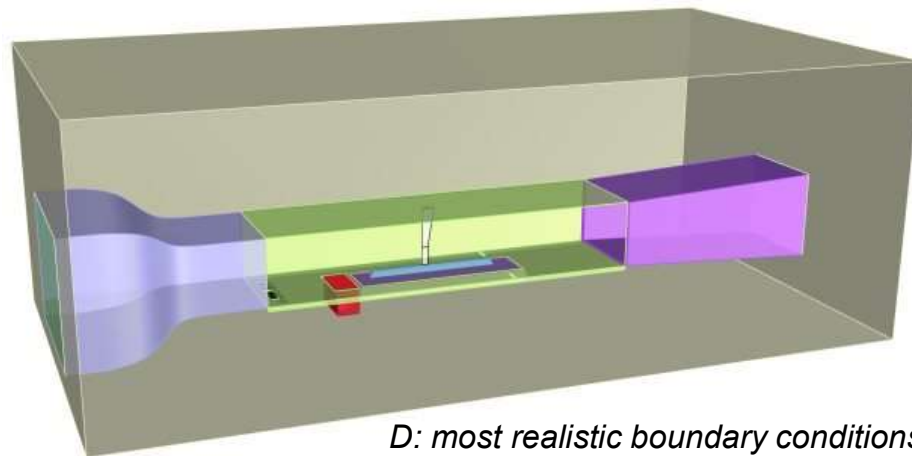
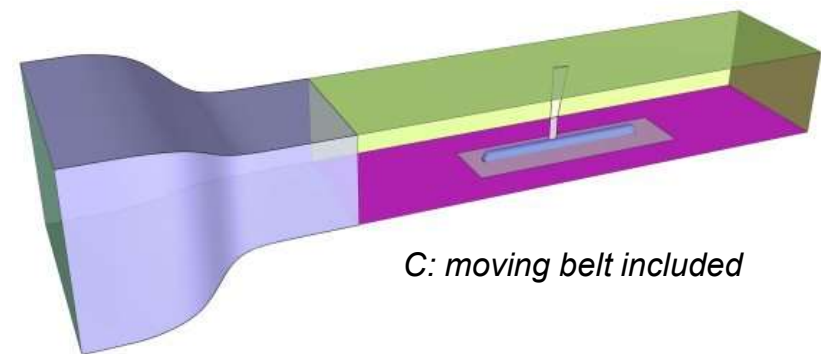
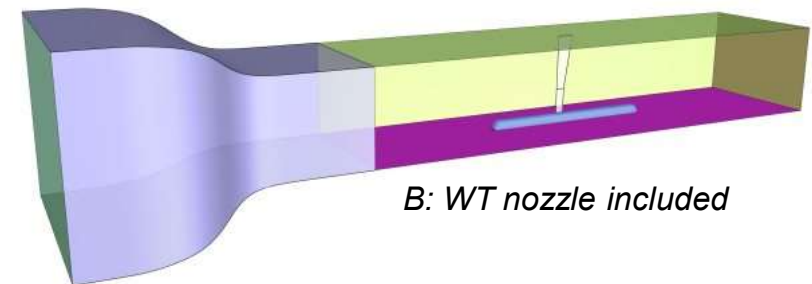
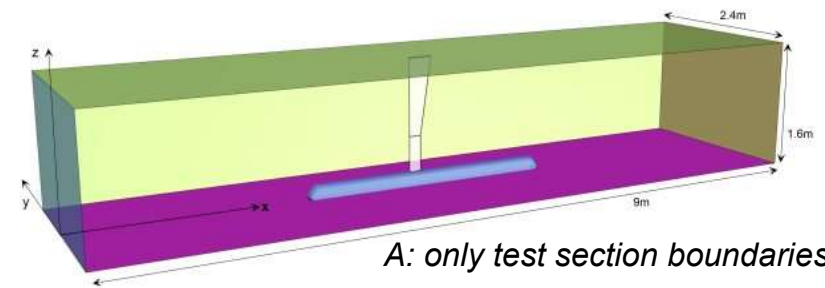


- model mounted on splitter plate and standard “Single-Track Ballast and Rail” (STBR)
- Yaw angle range $\beta = 0 \rightarrow \pm 180^\circ$
- Use of internal balances. Thus (besides the side forces) **drag** can be broken down into the individual contribution of each single car ([see paper RW.5.11](#))
- In comparison to SWG wind tunnel with moving belt ($Re=350.000$), the Prague VZLU wind tunnel allows for a Reynolds number of $Re=600.000$ (even for the smaller scale of 1:25)

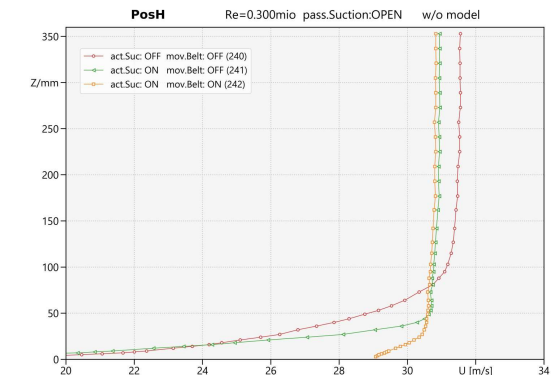
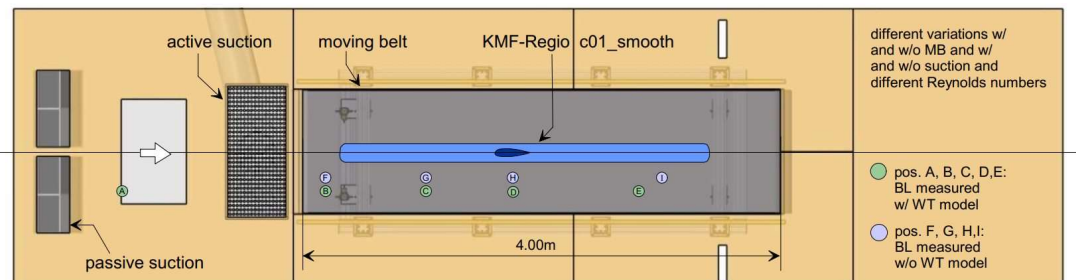
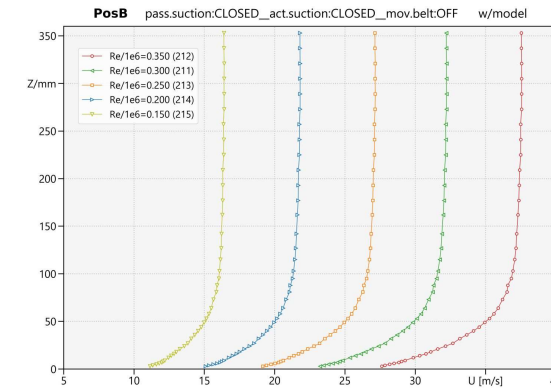
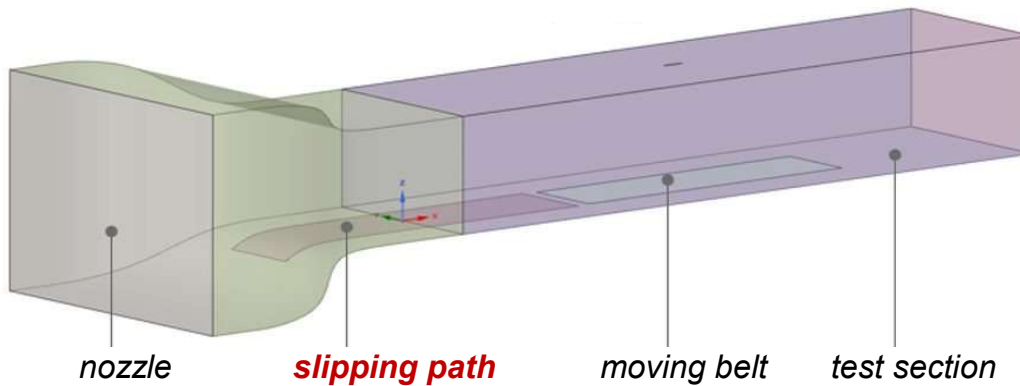
KMF-Regio for numerical simulations (CFD)



*real wind tunnel
(SWG w/ moving belt)*



The version favored most so far (within the Rail4Earth EU project)



- **Slipping path** upstream of moving belt for adjustment of boundary layer (*Stefan Wallin, KTH Stockholm*)
- Experimental boundary layer data available for different positions, w/ and w/o model
- No need to simulate BL suction. Influence of BL neglectable, when looking only on different roofs

Summary

- A generic, freely available model of a regional train was designed, and two wind tunnel models were built
- Experimental results of drag measurements for different, simple roof-box setups are available
- Experimental results from crosswind testing are available that also make it possible to determine the individual contribution of each car to the total drag
- Numerical simulations were performed in the framework of the “Rail4Earth” European project (the dissemination of the results is still pending)
- In-house numerical simulations of DLR for different configurations are work in progress



Future work

- Drag measurements in SWG with focus on other components than roof boxes
- Further evaluation of cross-wind measurements in the Prague VZLU wind tunnel
- Uploading and structured organisation of results (experimental and numerical) on the Zenodo-Server (<https://doi.org/10.5281/zenodo.19486416>)
- **Maybe, design of a KMF-DoubleDecker and/or KMF-HighSpeed generic model**



KMF-Regio
Kastentragendes Modulares Fahrzeug