

# The BESKID project: Design fire simulations in rail vehicles using AI-based data

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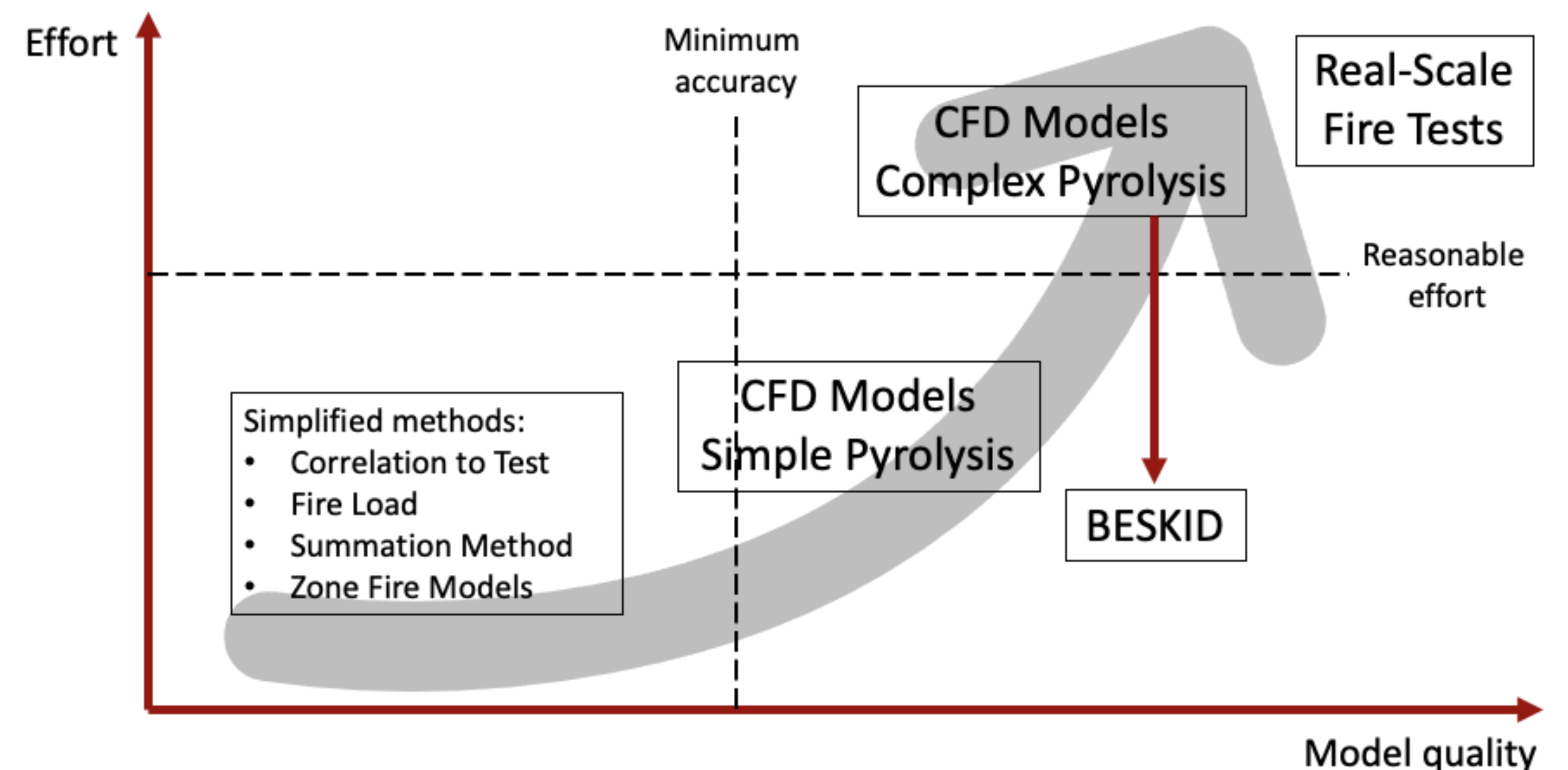
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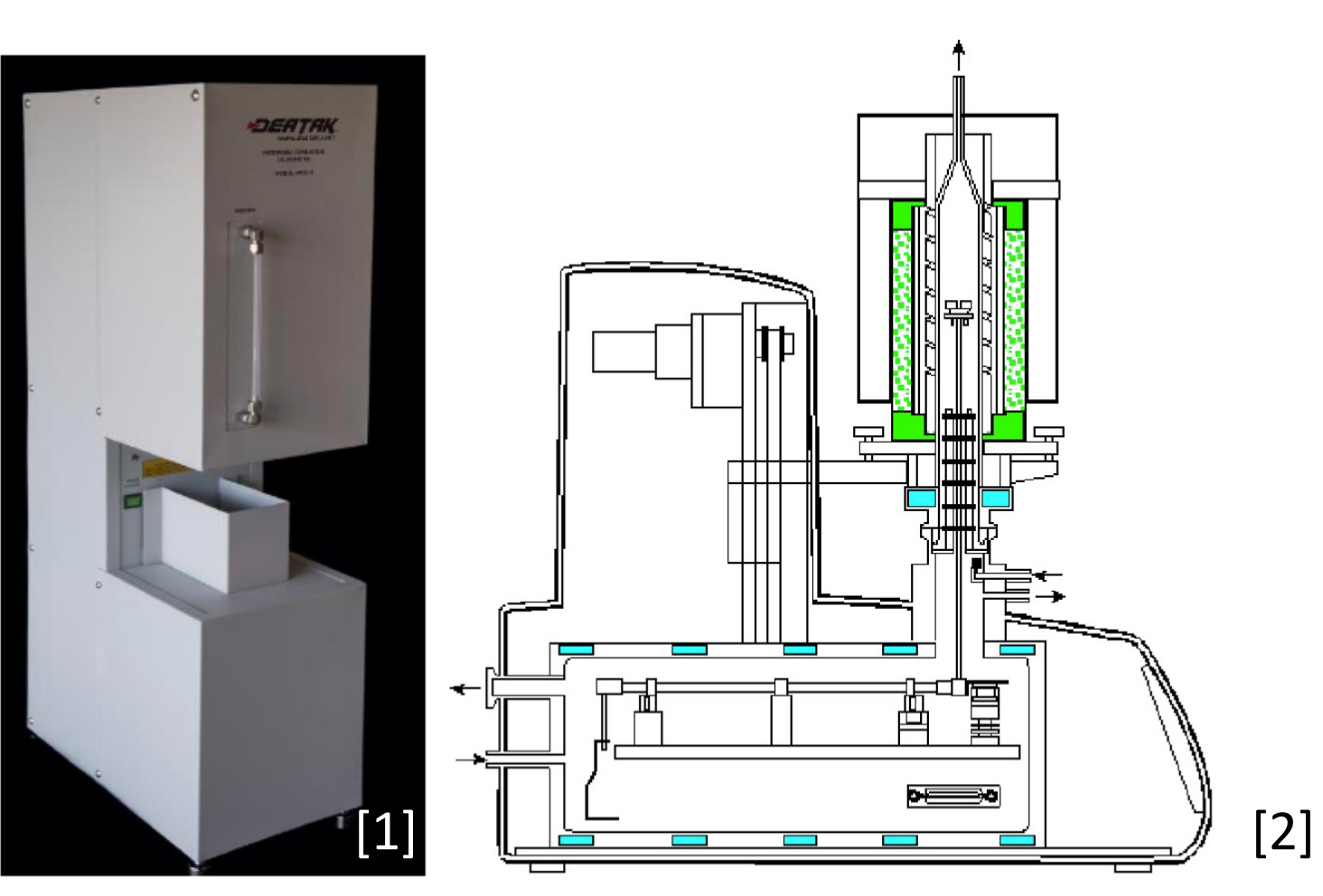
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The overall objective of the BESKID project is the development of two AI systems that allow to perform fire spread simulations, especially in rail vehicles based on less experimental data. With these scientific approaches, the calculation of design fires should be significantly simplified and accelerated to enable their practical application on a larger scale. The effort of such simulations should be reduced considerably, while maintaining or increasing the model quality. The use of more comprehensive simulations allows, among other things, the quantification of intrinsic and extrinsic influences as well as the effects of constructional and technical features of the vehicle on the course of the fire. For example, the effect of a ventilation or fire-fighting system on the fire progression can be quantified. The vehicle specific design fires allow an individual and optimized design of protective measures. However, the application of the findings and methods should not be limited to rail vehicles.

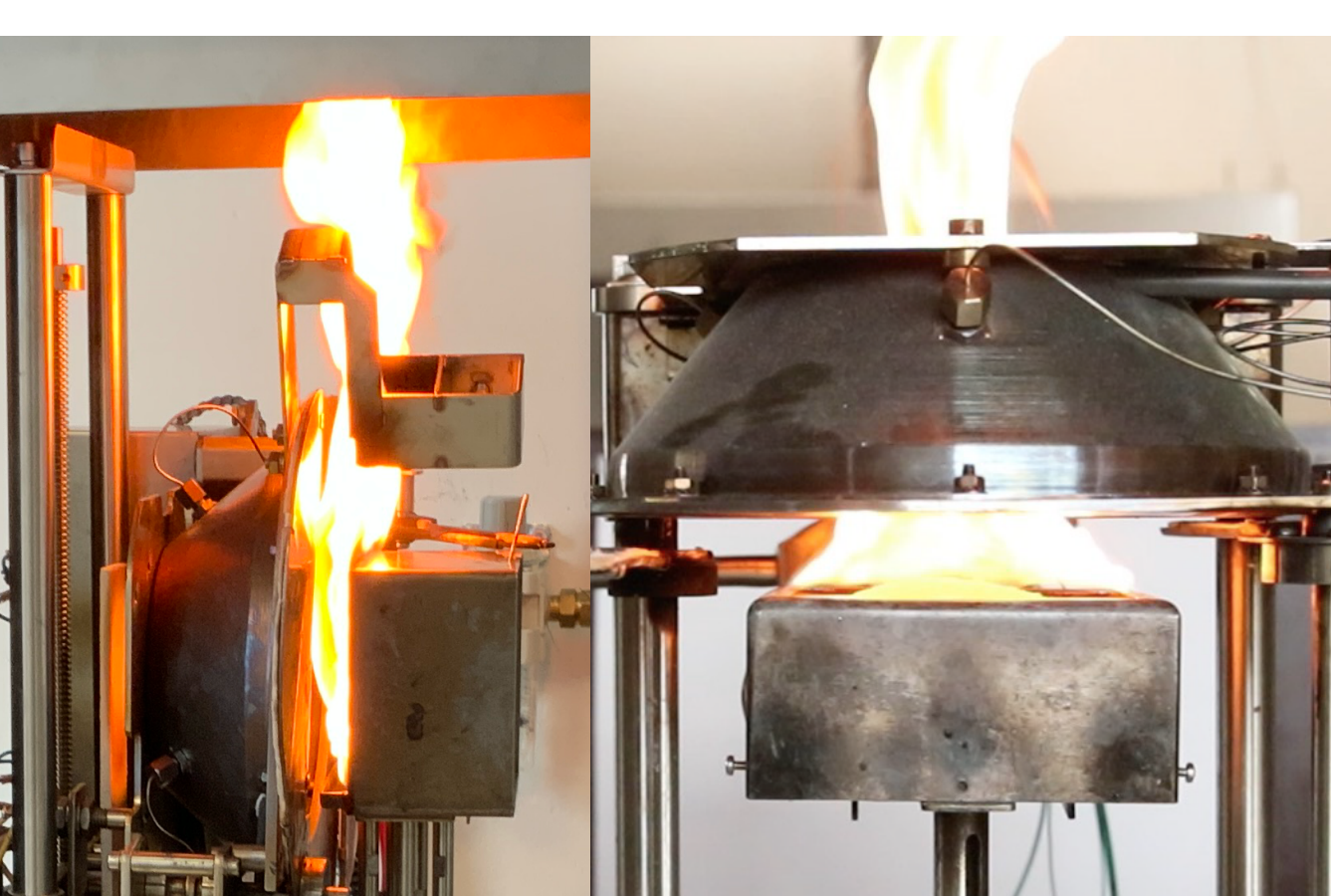


### MULTI-SCALE EXPERIMENTAL APPROACH

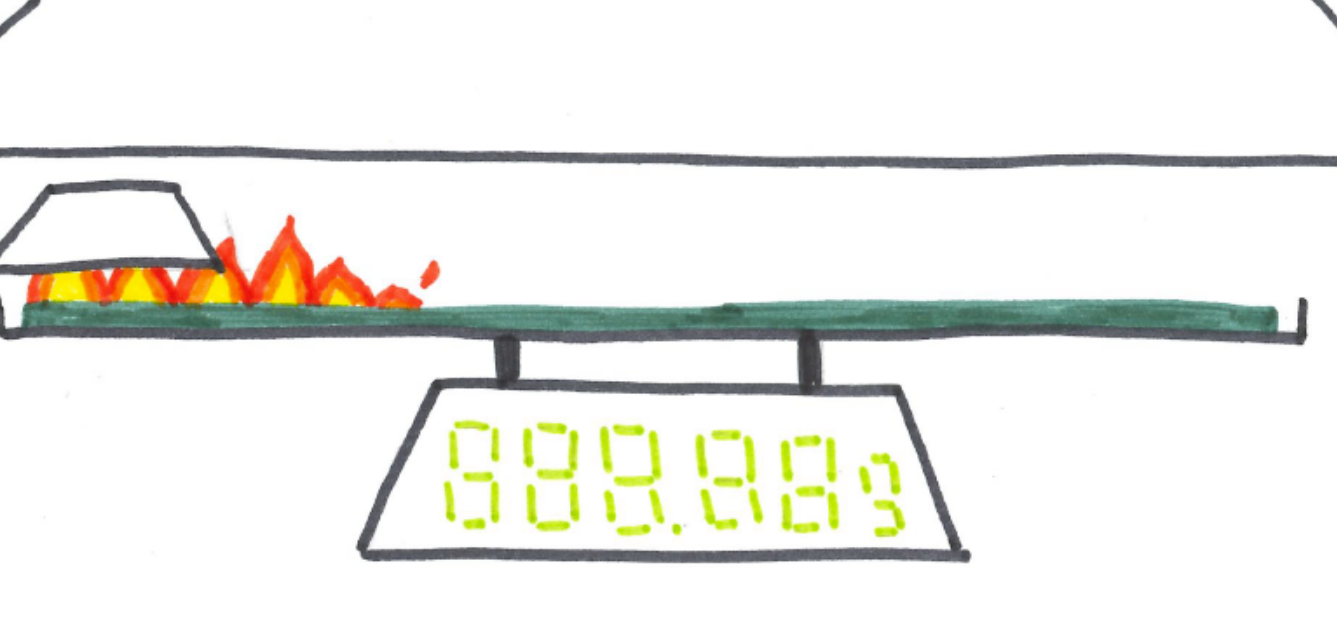
**MICRO SCALE: MCC AND TGA**  
→ i.e. REACTION KINETICS, HEAT OF COMBUSTION




**SMALL SCALE: CONE CALORIMETER**  
→ THERMO PHYSICAL PROPERTIES



**MEDIUM SCALE: HORIZONTAL FLAMESPREAD**  
→ FLAMESPREAD BEHAVIOUR



**LARGE SCALE: IDEALIZED GEOMETRIES - TRAIN CHAIRS**



[1] <https://www.deatak.com/instruments>  
[2] LINSEIS STA PT1600 Thermowaage Bedienungsanleitung, Linseis-Messgeräte. Selb.

### OVERALL APPROACH

**Classical approach:** Classical Parameter Estimation → Fire Dynamics Simulator + Complex Pyrolysis / Simple Pyrolysis

**Hybrid approach 1:** AI-M + Fire Dynamics Simulator + Complex Pyrolysis / Simple Pyrolysis + Database Material-parameters

**Hybrid approach 2:** AI-M + Fire Dynamics Simulator + Complex Pyrolysis / Simple Pyrolysis + Database Material-parameters + Database Fire Phenomena + AI-F

**Full AI-approach:** AI-M + AI-F + Database Material-parameters + Database Fire Phenomena

### AI-APPROACHES

**Artificial Intelligence for Material Parameters AI-M:** Data Collection (FDS-TGA/ Cone Calorimeter Simulations) → Data processing → AI-Model Training → Validation (Experimental Data) → Prediction of material parameters

**Reduced Order Model for Efficient Fire Spreading Simulation:** Utilizing the Reduced Order Model (ROM) in the BESKID Project for Fire Simulation in Train Compartments. ROM can provide rapid results and significantly decreases computational demands compared to Full Order Models (FOM) in the project phase.

**Artificial Intelligence for Flame Spread AI-F:** Synthetic Training Data (AI-Method: POD, RBF, DMD, NN, ...) → ROM Prediction → Providing ROM via Web

**Enhancement with Experimental Training Data**

**Key Points:**

- Different AI-Methods will be compared: Starting with POD and RBF
- Computational Advantage: Shifts need for computational effort to training data creation and can provide almost instant results in project phase.
- Training Process: Commences with the utilization of snapshots from synthetic data as the initial step. Additionally, there is potential for integration with experimental input for validation.

## ACKNOWLEDGEMENTS



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