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Center for Sustainable Future Mobility (CSFM)

Dynamic mechanical coupling's potential for a more sustainable railway operation

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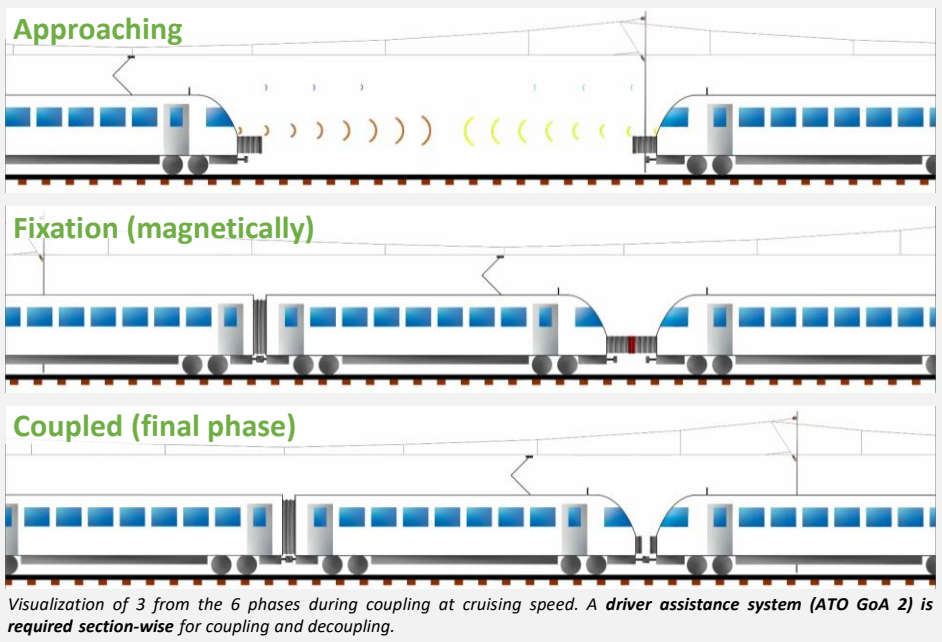
1 Introduction

The railway is a sustainable transport system. Due to climate change and political goals, the sustainability of the railway must also be further increased. **Dynamic mechanical coupling** is one technology that can help achieve these goals by reducing energy consumption, optimizing space usage and contributing to a modal shift to the railway.

2 What is dynamic mechanical coupling?

Train Unit Coupling in Operation (UCO) can be classified into four generations; the first two UCO generations describe the classic coupling at a standstill. UCO generation 3.x is the virtual coupling. UCO generation 4.x describes the dynamic mechanical cou**pling** and decoupling of a railway running at cruising speed (for all details, read [1]). Technologically, UCO 4.x require support systems combined with driver assistance systems (or ATO GoA 2).



*Visualization of 3 from the 6 phases during coupling at cruising speed. A **driver assistance system (ATO GoA 2) is required section-wise** for coupling and decoupling.*

Due to the mechanical coupling while driving, completely new approaches are emerging which can have a positive effect on sustainability, as described below.

3 Energy saving

The energy consumption can be reduced using the train separation of dynamic coupling (UCO 4.1). In extreme cases, this can reach up to 65% (see [3]). The energy saving results from a combination of the following:

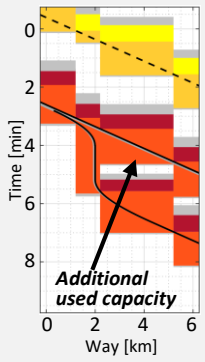
- Avoiding losses due to decelerations and accelerations (also by 100 % regeneration losses occur due to the limited engine efficiency). [2, 3]
- Avoiding vehicle front/rear resistance due to coupling of vehicles. [4]
- Optimized vehicle size along the trip (portion size). [3]
- Enabling lower and homogenous speed (by the same travel time). [3]

4 Increase capacity usage

The mechanical coupling enables the bundling of trains. During the coupled section, mechanical coupling reduces the distance between the trains to 0. As a result, higher capacity utilization enables more passengers on similar infrastructure, positively affects space usage, and can help avoid large Swiss-wide new railway lines because it requires only section-wise new tracks.

Example for capacity usage of not coupled trains between C1 and K1 (source [1])

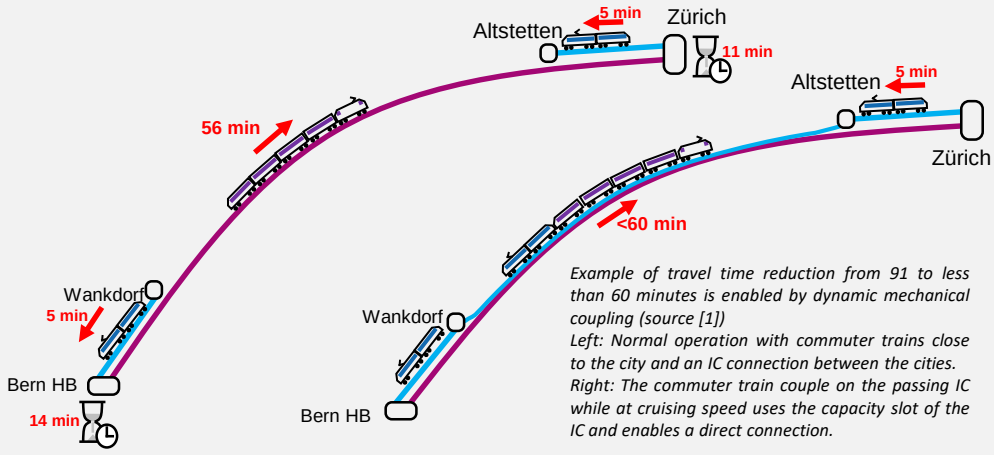
Example for capacity usage of coupled trains between C1 and K1 by separating at K1 (source [1])



Example of separation short before one train stops for passenger exchange and the other continues (source [3]).

5 Modal shift to rail because of travel time reductions and direct connections

Dynamic mechanical coupling can enable shorter direct connections without transfers (see example picture and [1]).



Example of travel time reduction from 91 to less than 60 minutes is enabled by dynamic mechanical coupling (source [1])
Left: Normal operation with commuter trains close to the city and an IC connection between the cities.
Right: The commuter train couple on the passing IC while at cruising speed uses the capacity slot of the IC and enables a direct connection.

5 Conclusion

- Dynamic mechanical coupling can have significant potential. It can save energy, reduce travel time, enable direct connections without building new railway lines, and impact a modal shift to rail as a pull measure.
- Implementation also requires a section-wise driver assistance system (ATO GoA 2) during coupling and deco
- Today, many research questions are unanswered (see research agenda of [1]).

References

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