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Center for Sustainable Future Mobility (CSFM)

Driver assistances systems can help energy saving in railway operation

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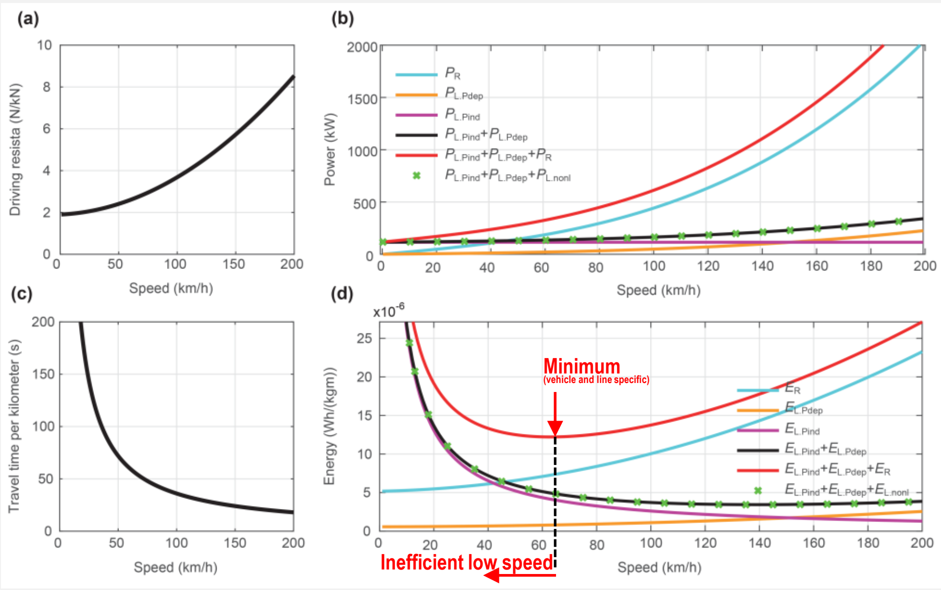
1 Introduction

Energy is one relevant topic for future railways [1]. The railway is a very energy-efficient transport system. Due to climate change and political goals, the sustainability of the railway must also be further increased. **Driver assistance systems up to ATO GoA 2 can help implement energy-saving measures** such as **energy-efficient train control** (**EETC**). EETC adjusts the trajectory by using the available timetable buffer so that the train arrives at its destination on time. In addition, it should not affect other trains.

2 RMS vs. EETC

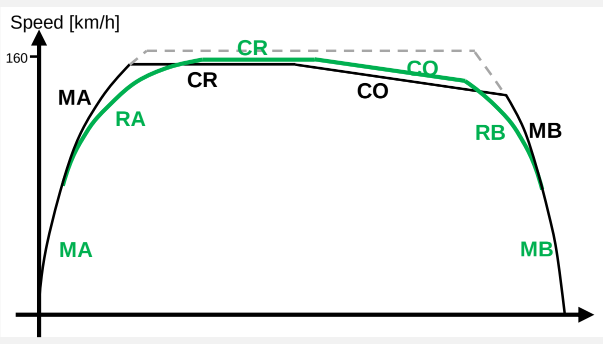
The highest energy saving can be achieved by using (EETC). EETC should not be confused with a **reduction in maximum speed** (RMS). In terms of implementation, RMS is simple. However, EETC saves more energy than RMS (4.9 % more on an exemplary test case simulation, which is due to high speed level advantageous for RMS). Moreover, in cases that are not advantageous for RMS, RMS can increase energy consumption because of an energy-efficient minimum speed. [2-5]



Quantification of the values to drive different constant speeds for determining the vehicle and line specific energy efficient minimum speed. **a)** specific driving resistance; **b)** different kinds of power versus speed; **c)** travel time per kilometer versus speed; **d)** Pareto front of specific energy consumption to drive 1 km (Source [5])

3 EETC

EETC, calculated on simple models, consists of 4 modes with switching points. If the EETC includes vehicles' specific details, such as the dynamic efficiency, it consists of 6 modes and saves more energy.

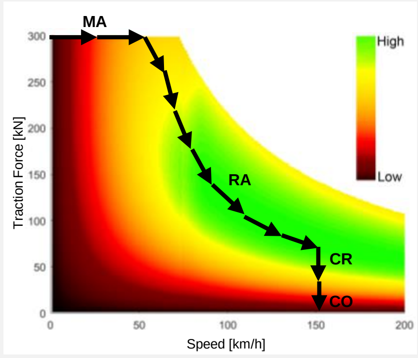


Exemplary trajectory of energy-efficient control. Black with 4 modes, and green change with 6 modes (grey day dashed is driving with maximum speed). (compare [3])

MA	Maximal acceleration
CR	Cruising (constant speed)
CO	Coasting (zero traction)
MB	Maximal service braking
RA	Reduced acceleration
RB	Reduced braking

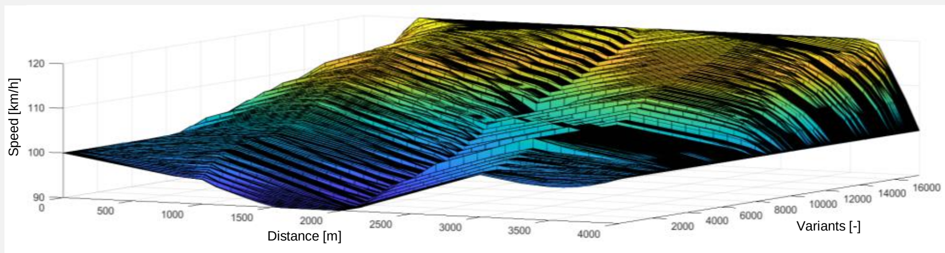
4 Complexity of EETC

Energy saving is complex in many respects. This starts with the different switching points between the modes and their dependence on aspects like the timetable buffer and the route (gradient, wind). In addition, the efficiency of vehicles is not constant; it is dynamic [2-5]. As a result, the two energy-saving increasing modes, reduce acceleration (RA) and reduce deceleration (RD), require a specific speed-dependent tractive force.



The arrows show the path through the energy-efficient (green) areas of the tractive force diagram by RA. (Source [5])

As a result, the optimal trajectory usually consists of varying speeds.



Example of Different trajectories depending on the travel time buffer (Source [2])

5 Interaction with other trains

Mutual interference is possible if the route is used by several trains and above a certain train density. Energy optimization must e.g.:

- prevent trains from stopping unnecessarily because this requires a lot of energy;
- must consider that the optimal trajectory of one train does not influence other trains because it should be avoided that one train saves energy, and other trains consume more energy than saved.

6 Conclusion

- Energy-efficient driving is very complex and requires system-wide coordination.
- Driver assistance systems for energy-efficient driving are required to keep it manageable for the driver. Otherwise, there is a risk that the driver will no longer be able to concentrate on safety and line.

References

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