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Using simulation to assess the benefits of energy-efficient driving strategies

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Abstract

EnergyMiser is an in-cab system that calculates energy-efficient driving strategies to move a train to key destinations on time and with minimum energy use. To assess and demonstrate the potential benefits of EnergyMiser for a railway, we need a method that can make valid comparisons between observed journey profiles without EnergyMiser and the journey profiles that EnergyMiser would advise.

With a sufficiently detailed model, it is possible to use a sequence of observed throttle and brake settings and simulate the motion of the train. The key simulation parameters are the tractive and braking forces generated by the locomotives, the length and mass distribution of the train, coefficients of rolling resistance and aerodynamic drag, track gradient, track curvature and speed limits. In practice, some of these parameters will not be known precisely, and indeed may vary during the journey, and so the calculated speed profile will inevitably differ from the observed speed profile.

We propose a more robust method, which compares the mechanical work done by the locomotives to follow observed and optimal speed profiles. For any speed profile, the mechanical work done on each small segment of the journey is the sum of three components: the change in kinetic energy, the change in potential energy, and the work done against resistance. If this sum is positive then the work has been done by the locomotives; if the sum is negative, the work has been done by the brakes. If the calculation of the work done to overcome resistance is reasonable and the same resistance parameters are used with each of the speed profiles, we can compare the mechanical work done by the locomotives.

We can use this method to compare observed speed profiles with speed profiles calculated by EnergyMiser. Each EnergyMiser profile is adjusted so that the overall journey time matches the time taken by the corresponding observed speed profile. By taking a representative sample of observed journeys and calculating corresponding EnergyMiser journeys, we can predict the potential energy savings offered by EnergyMiser.