Effect of Aerodynamic and Lightweight Double-Deck Trailers on HGV Fuel Consumption

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There are numerous technological opportunities in the short to medium term to improve fuel efficiency of HGVs [1]. While tractors are often the focus for fuel efficiency technologies, trailers are generally considered as an afterthought due to their lower cost. Trailers play a vital role in road freight [2] and should be included in strategies to reduce carbon emissions produced by the sector [3]. Several trailer technologies are available to reduce fuel consumption: low rolling resistance tyres, aerodynamic packages to reduce drag, and light-weighting using alternative materials to increase payload [4].

Aerodynamic drag is a significant component of energy consumption, particularly in long-haul operations due to the high average speeds [5]. The aerodynamic drag is dependent on not only the design of the tractor and trailer, but also the interaction between them. In [6], the four primary sources of aerodynamic drag and their respective percentage contributions for a tractor-trailer were outlined: the tractor front (25%), the gap between the tractor-trailer (20%), the trailer's underbody (30%), and the rear of the trailer (25%).

Reducing the mass of the tractor-trailer combination can facilitate an increase in payload. The most practical area for manufacturers to reduce trailer mass in the short-term is by using lightweight composites for trailer decking and side walls [7]. In [3], a study was carried out to assess the potential for improving trailer design through light-weighting and found an opportunity for double-deck trailers.

This work focuses on evaluating a new Lightweight and Aerodynamic Double Deck (LADD) trailer developed through the Low Emissions Freight Trial in the UK. The consortium for the project comprised Lawrence David Ltd, SDC Trailers Ltd, Tesco plc and University of Cambridge.

The aerodynamic features were introduced by Lawrence David Ltd and Aerodyne Global Ltd. At the rear end of the trailer, there is a tapered 1.48 m long boat tail at an angle of 4.5 deg. Wind tunnel tests on a scaled down HGV prototype with the boat tail, showed approximately 3.4% reduction in the coefficient of aerodynamic drag [8]. The front end of the trailer has a deflector and fin, which showed approximately 2.5% and 2.4% reductions, respectively, in these wind tunnel tests. Together, the three aerodynamic features reduced the aerodynamic drag by approximately 8%.

Light-weighting was achieved by modifications to the chassis (introduced by SDC Trailers), and by light-weighting the body using lighter materials for the lower and upper decks and for the sidewalls of the semi-trailer (introduced by Lawrence David). The prototype light-weight trailer weighed 8.8 tonne compared to the baseline weight of 11.3 tonne, i.e. a reduction of 2.5 tonne. However, shortly after commencing transport operations, the trailer sidewalls and decks developed defects. Modifications to rectify these defects are ongoing. In this article, we assume a reduction 1.5 tonne from light-weighting, including one tonne from the proven chassis improvements and 0.5 tonne from body light-weighting.

The trailers were operated on long-haul deliveries by a supermarket company in the UK, Tesco plc. In this work, these vehicles were evaluated using in-service data, and computer-based simulations with coefficients of aerodynamic drag and rolling resistance estimated from coast-down tests conducted at a test track in England, Horiba Mira Ltd. Compared to a baseline trailer, the coast-down tests showed that the aerodynamic features reduced the coefficient of aerodynamic drag by approximately 7.2% and that the single wide tyres on the lightweight trailers reduced the coefficient of rolling resistance by approximately 10%. The in-service trials showed a 2% reduction in fuel consumption associated with the aerodynamic features of the trailer, using a multi-linear regression to model the changes in other factors including average speed and payload. The relatively modest fuel savings are associated with the drive cycle for these trials, which did not use the most beneficial trunking routes for logistical reasons.

Based on simulations using the coast-down data results, the aerodynamic trailer is predicted to reduce the HGV's fuel consumption by approximately 4.7% while cruising on UK motorways at 84 km/h and by approximately 3% for the long haul drive cycle from the Low Carbon Vehicle Partnership (LowCVP) in the UK. The lightweight trailer is predicted to reduce the HGV's fuel consumption by approximately 15.1% while cruising on motorways at 84 km/h and by approximately 14.3% for the LowCVP long haul drive cycle. The aerodynamic-lightweight trailer is predicted to reduce the HGV's fuel consumption by approximately 19.3% while cruising on motorways at 84 km/h and by approximately 16.9% for the LowCVP long haul drive cycle.

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