

Intelligent Predictive Cruise Control Application Analysis for Commercial Vehicles based on a Commercial Vehicles Usage Study

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ABSTRACT

With the introduction of advanced digital road maps, which include information on the slope and curve radius of the highways, predictive control for standard and hybrid commercial vehicles, based on these maps, is about to be released by the vehicle manufacturers. For example, intelligent predictive cruise control has been announced for introduction in 2012 by Scania and Daimler. In addition, hybrid commercial city buses like MAN's Lion's City Hybrid have already been implemented. But the question remains about the type of vehicle suitable for the implementation of predictive intelligent concepts, due to the high investment cost compared to the sometimes relatively low operating cost savings. This study analyses usage and performance data collected from approximately 20,000 commercial vehicles, which include long distance trucks, distribution trucks, city buses and coaches, in order to answer the question which vehicle types should be equipped with intelligent predictive cruise control considering an economic reasonable return on investment.

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INTRODUCTION

Rapidly decreasing reserves of oil and other fossil fuels is forcing research into the reduction of fuel consumption: a decrease in fossil fuel exploitation will lead to increasing fuel prices, which has a major impact on the total cost of ownership (TCO) for vehicles [1,2]. In addition to increasing fuel prices, the implementation of new environmental

restrictions is compelling vehicle manufacturers to decrease the average fuel consumption for the commercial fleet. A clear and conclusive strategy is needed to find the most viable method for fuel reduction when designing a fleet of commercial vehicles, in terms of both, control strategy (intelligent predictive cruise control or hybrid drive-train concepts etc.) and vehicle types (long distance trucks, coaches etc.).

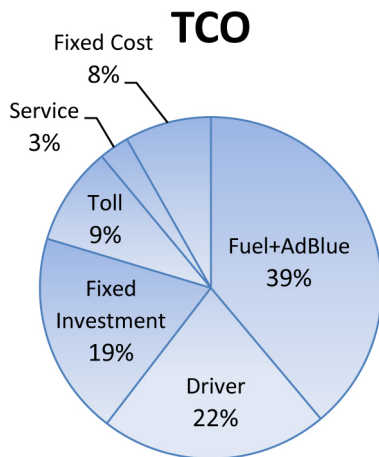


Fig. 1. 1 Approximated total cost of ownership for long distance trucks.

Total Cost of Ownership

The long distance truck and haulage market is a particularly highly competitive one with small profit margins, dependant greatly on TCO reduction. A rough estimate of the TCO structure for a long distance truck is shown in Fig.1. The chart is based on detailed data for a MAN TGX truck with an annual mileage of 150, 000km/year. For example a 4% saving in fuel and AdBlue is approximately 2900€/year and reduces the TCO by 1.6%¹. As a consequence, customers tend to buy a truck (or a bus) with the lowest TCO rating.

Fuel is one of the main TCO elements and in order to boost sales, truck manufactures are being forced into a race towards minimum fuel consumption, lower service costs and sophisticated finance for their customers.

Environmental Restrictions

At present, legal restrictions in terms of exhaust gases focus on reduction of NO_x and particles, as outlined in the Euro 6 legal requirements [3]. Future regulations will also introduce limitations in terms of CO₂ emission levels, as can be deducted from a European Commission paper [4]. CO₂ reduction for a truck manufacturer is mainly achieved by a measurable reduction of fuel consumption, e.g. diesel releases 2.63kg CO₂/litre. The exact level of CO₂ reduction planned for 2030 is not set at present, but the enforcement is expected.

In order to evaluate the fuel consumption and potential savings, the MAN fleet monitoring system is being used in this paper. The system was implemented in the year 2000 in all MAN heavy trucks and later in medium range/distribution trucks and all types of MAN buses and coaches. The data analysis from approximately 20,000 commercial vehicles is presented in the following sections and based on this analysis, recommendations for the implementation of the intelligent predictive cruise control and hybrid concepts are made.

DATA MONITORING

MAN fleet monitoring is an on-board system that records basic operating conditions e.g. the ambient air temperature and more. It classifies the data by the time of operation or the driven mileage within a certain range, for example. The aim is to classify the operating conditions of the vehicle and to be able to make conclusions about wear, lifetime and changing usage. The data sampled includes:

- Time, mileage and fuel consumption with active cruise control, active adaptive cruise control, active speed limiter and acceleration pedal.
- The fuel consumption in different speed classes for different operating conditions.
- The engine torque over engine speed and gear.
- The times and mileage travelled in a certain gear.
- The gears used for pull out/start.
- The estimated energy that remains in the clutch during shift processes.
- Various pressures and temperatures.

The above list is an extract from the overall much greater set of data.

The data is stored on the main electronic control unit (ECU) of the vehicle and is uploaded to the MAN server during maintenance in a MAN service station. The files can then be downloaded from the server database and MATLAB based tools are used to process them and calculate overall fleet data, which can be plotted in histograms or exported to MS Excel. The data is anonymous and no customer information can be tracked.

FUEL SAVING STRATEGIES, REQUIREMENTS AND POTENTIAL

The two fuel saving strategies considered in this paper are:

Predictive Control

Intelligent cruise control and adaptive cruise control strategies both use digital road maps with slope and curve radius information to calculate optimal fuel speed trajectories using predictive control [5], [6], [7], [8], [10], [11] and [12]. Preconditions for the successful implementation of this strategy are: a high annual mileage on motorways with significantly changing slopes and a vehicle weight larger than 20tonnes. This is a low investment strategy as it requires only digital road maps, software and some computing capacity. It can be extended to predictive control of auxiliary devices and

¹Data from the TCO analysis.