

Analysis of Lateral Dynamics and Ride Performance of the Superbus

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ABSTRACT

Vehicle handling and stability are very important at high speeds especially when the vehicle has a weight of about 6 times a normal luxury passenger car as in the case of the Superbus which travels at 250kph.

In this paper the high speed performance of the Superbus will be analyzed. First the model will be discussed. Then, a number of the several analyses that were carried out will be discussed. These include single lane change and steering impulse. The simulations were done with a complete multibody model made in ADAMS, which accounts for all the major non-linearity's of the actual vehicle, such as air springs and shock curves, suspension bump stops and Pacjeka tire model [1]. The results of these analyses show that the Superbus is a safe vehicle to drive at high speeds and still can be very comfortable.

INTRODUCTION

There should be a solution to the continuous traffic increase and related pollution. One possible solution for this is the Superbus. The Superbus is a new concept vehicle [2] which is fully electric, operates at 250 kilometers per hour cruising speed and it is aimed at increasing public transportation with respect to private mobility. The Superbus travels at high speeds on specially designated roads (namely the supertracks) and at lower speeds on existing roads. This constitutes a significant novelty in public transport as passengers will not have to change transportation means from departure point to arrival point. The Superbus can transport 23 persons safely and comfortably at high speeds. It has three axles, for a total of six rubber-tired wheels. With a length of 15 meters and a width of 2.5 meters, the Superbus has similar dimensions to a conventional bus but the height is just 1.6 meters. This is due to reduce frontal area for aerodynamic performance, to lower the center of gravity for vehicle stability and to define more individual and comfortable personal areas. The low frontal area combined with a highly streamlined body

shape has allowed obtaining a low coefficient of aerodynamic drag so to optimize energy consumption. The vehicle has 16 doors, 8 placed along both sides of the vehicle to allow direct access to all seats. The Superbus will be operated by the combined use of a driver and vehicle electronic guidance. Indeed, the vehicle is equipped by a sophisticated navigation, obstacle detection and adaptive cruise control systems. The road surface of the dedicated concrete supertracks will be heated during winter, to prevent the formation of icing, using solar heat stored in the summer. This eliminates the chance of slippery and unsafe road conditions.

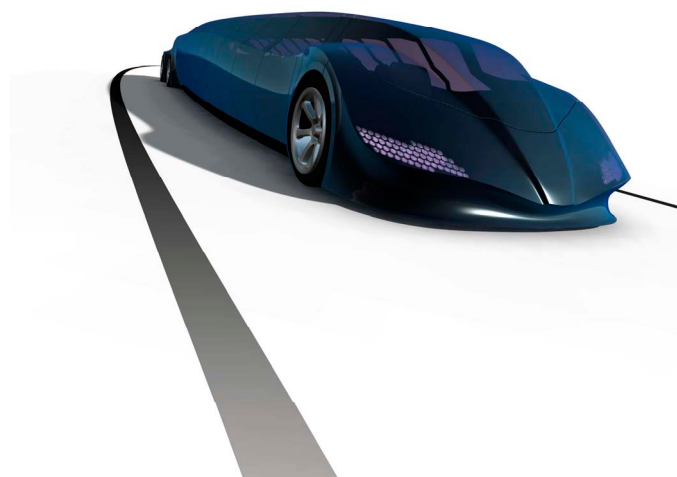


Figure 1: The Superbus

In the winter of 2005/2006 the possibilities for application of the Superbus on the Zuiderzeelijn were investigated. The Zuiderzeelijn is the intended fast connection between the West and the North of the Netherlands. In this investigation the Superbus was compared to other means of high speed public transport like the magnetic levitation train, fast intercity services and high speed

trains. The Superbus was found to be the best in comparison to other means of transport. Therefore the Dutch government decided upon a research and development program for the Superbus. The first phase [3], which is partly funded by the Dutch government, is aimed at the realization of a fully functioning demonstration vehicle to be launched at the Olympics 2008 in Beijing. The Superbus is a joint project of a number of faculties within the Delft University of Technology in the Netherlands (including Aerospace Engineering, Industrial Design Engineering, Electrical Engineering, Mechanical Engineering, Civil Engineering) a number of institutes and of companies for a total of 36 groups.

This paper concentrates on the modeling of the suspension system of the Superbus and the analyses carried out through the design phase. The suspension is one of the most important parts of a vehicle because it contributes to the safety and to the comfort. The novelty of the Superbus vehicle has required a tailored suspension system to account for the various operational conditions. Indeed, especially at high speeds, the vehicle has to operate in a comfortable way but also perform a good handling in emergency scenarios.

MODEL

PRINCIPAL ASPECTS OF THE SUSPENSION SYSTEM

The Superbus has three axles, one axle in the front and two driven axles in the rear. All axles have independent double wishbone suspension. All wheels can be steered up to 40 deg to allow the vehicle to perform a turning circle of less than 12.5 meters – as requested by the European road regulations. The rear wheel steering system will only be used at low speed.

The Superbus ground clearance can vary from 60mm to 400mm. This is done through the use of the custom made VB-Airsuspension system and of a hydraulic lifting system between subframes and body. The vehicle will travel at the lowest ground clearance on the supertrack, when running at height speed, and in some circumstances when loading the passengers. However, to avoid road bumps in the city center or other obstacles, the Superbus will be raised up to 400mm, see Figure 2. Needless to say, the adjustable ground clearance will also allow the alignment with any platform so to enhance accessibility. The variable vehicle height is obtained as follows. Starting from the lowest ground clearance of 60mm, the use of air-springs will allow the ground clearance to be increased by an additional 60 mm. From 120mm, the hydraulic lifting system will increase the ground clearance of an additional 280 mm to reach a total ground clearance of 400mm.



Figure 2.: Ground clearance variation

The dampers implemented in the vehicle are supplied by KONI and are frequency selective. These frequency selective dampers (FSD) have different damper characteristics for low and high frequencies which give them a stiffer handling at cornering and a softer comfort at bad quality roads, see Figure 3.

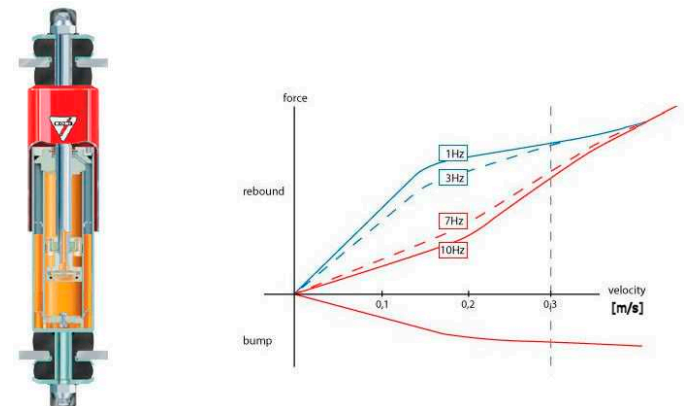


Figure 3: Koni FSD damper characteristics

The tires are custom developed by Vredestein and are 315/50-22 tires. Due to the operational characteristics of the Superbus, it was chosen not to implement run flat tyre technology mainly for weight and comfort penalties. The wheel-rims are custom developed by Dymag and will have a magnesium hart and a carbon rim to keep the total weight under 16kg and able to withstand a static load of 1600kg, see Figure 4. The braking systems components will be as well lightweight due to the use of carbon-ceramic brake discs, which will also make it possible to brake up to 1.2g. As a result of the use of custom developed lightweight tires, wheels, and braking system the overall unsprung weight is less than 150kg.