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JOHN AURELL

THE LATEST IN WIDE SINGLE TRENDS FROM EUROPE

Effects of wide single tyres and dual tyres

John Aurell
Volvo Truck Corporation

Summary

In the never-ending effort to make road transportation more effective wide single tyres have gained large popularity on trailers in Europe. Axles with heavier loads, like drive axles, are currently always equipped with dual tyres. The interest in using single tyres also on drive axles is however emerging.

There are several advantages for the transport economy with wide single tyres compared to dual tyres. One is lower rolling resistance, which reduces the fuel consumption. Another one is lower weight, which increases the payload.

If the reduction of the rolling resistance is 20 %, the fuel-saving (*FS*) can be calculated from the following equation.

$$FS = 0.40 \times 0.20 \times \frac{STAL}{GCW},$$

where $STAL$ is the summed axle load on axles with single tyres.
For example if the dual tyres on the drive axle of a 5-axle tractor-trailer combination are replaced with singles, the fuel-saving is 2 %. If duals on the three trailer axles are replaced, the fuel-saving is 4 %.

In order to examine the effects on the vehicle behaviour, complete vehicle experiments were performed. Various standardised tests in order to determine both steady-state characteristics and transient response characteristics of heavy vehicles, whose drive axle was equipped with wide single tyres or with dual tyres, were carried out. The yaw stability may be studied both from steady state responses and from transient response characteristics. For a single unit vehicle the stability is related to the understeer/oversteer characteristics. The understeer or stability gradient expresses how the steer angle is related to the lateral acceleration in a steady-state turn. If the stability gradient is negative there is a critical speed when the vehicle is unstable. The stability gradient is obtained from a handling diagram. There may be a linear relationship between steer angle and lateral acceleration, but due to non-linear tyre effects, it is often non-linear. This is illustrated in Figure 1, which shows handling diagrams from tests with a two-axle rigid vehicle with air suspension (Volvo FH10) with dual (Michelin 315/70R22.5 XDA) respectively wide single tyres (Michelin 495/45R22.5 XDA) on the rear axle. The front axle had Michelin 315/70R22.5 XZA. It appears that while the relationship with singles is rather linear, it is very non-linear with duals. This implies that the stability gradient as shown in Figure 2 varies a lot with the lateral acceleration for duals but is more or less constant for single tyres. The vehicle equipped with single tyres has a much larger stability margin. The transient response characteristics are shown in Figure 3. It appears that there is a noticeable difference. The response time expressed as phase time is significantly shorter with single tyres. This improves the perception of the handling qualities. The reason for this improvement is that the cornering stiffness is higher for the wide single tyres and that the single tyres have a more linear characteristic than twin-mounted tyres.

The impact on dynamic wheel forces, which are of importance, both for the road-holding of the vehicle as for the road wear, was examined on the Volvo road simulator with the same vehicle. A road profile corresponding to a rough road was used. The coherence between the two wheel tracks was natural, i.e. long wavelengths are coherent and short wavelengths are incoherent. Autospectra of the wheel forces for the two tyre sets are shown in Figure 4. It appears that the difference around the body-bounce frequency is negligible while there is quite a large difference at the axle-hop frequency. Figure 5 shows that the dynamic forces expressed as rms-values are 17 % higher with dual tyres than with wide single tyres. The reason for this reduction with singles is probably that the vertical stiffness and the suspended mass are lower for the single tyres. This hypothesis is confirmed by the results in Figure 6 which shows autospectra obtained with a mathematical vehicle model for the baseline and for the case where the tyre stiffness is reduced with 20 % and the axle mass with aproximately 10%.

Another more obvious benefit with single tyres is that the rollover stability is increased. The rollover limit can be determined by the following equation

$$RoL = \frac{T}{2H} - \Phi,$$

where T is the track width, H the centre of gravity height and Φ various compliances.
With the track width increased from 1.830 to 2.005 the rollover limit is increased with almost 10 %.

One disadvantage with wide single tyres may be that the road wear is higher. Current research shows however that this is not always true. The table below shows what parameters that affect different kinds of road wear and the wear ratio between singles and duals. The load is the same in this comparison.

Type of road wear	Parameters affecting the road wear	Road wear ratio Singles/Duals
Primary rutting	Width Length (Pressure)	Equal
Secondary rutting	Total width Length (Pressure)	Somewhat more
Cracking	Total width Length (Pressure)	Somewhat more

Primary rutting occurs on roads with thick pavement, secondary rutting and cracking on roads with thinner pavement. The pressure is shown within parentheses because it is a function of width and length.

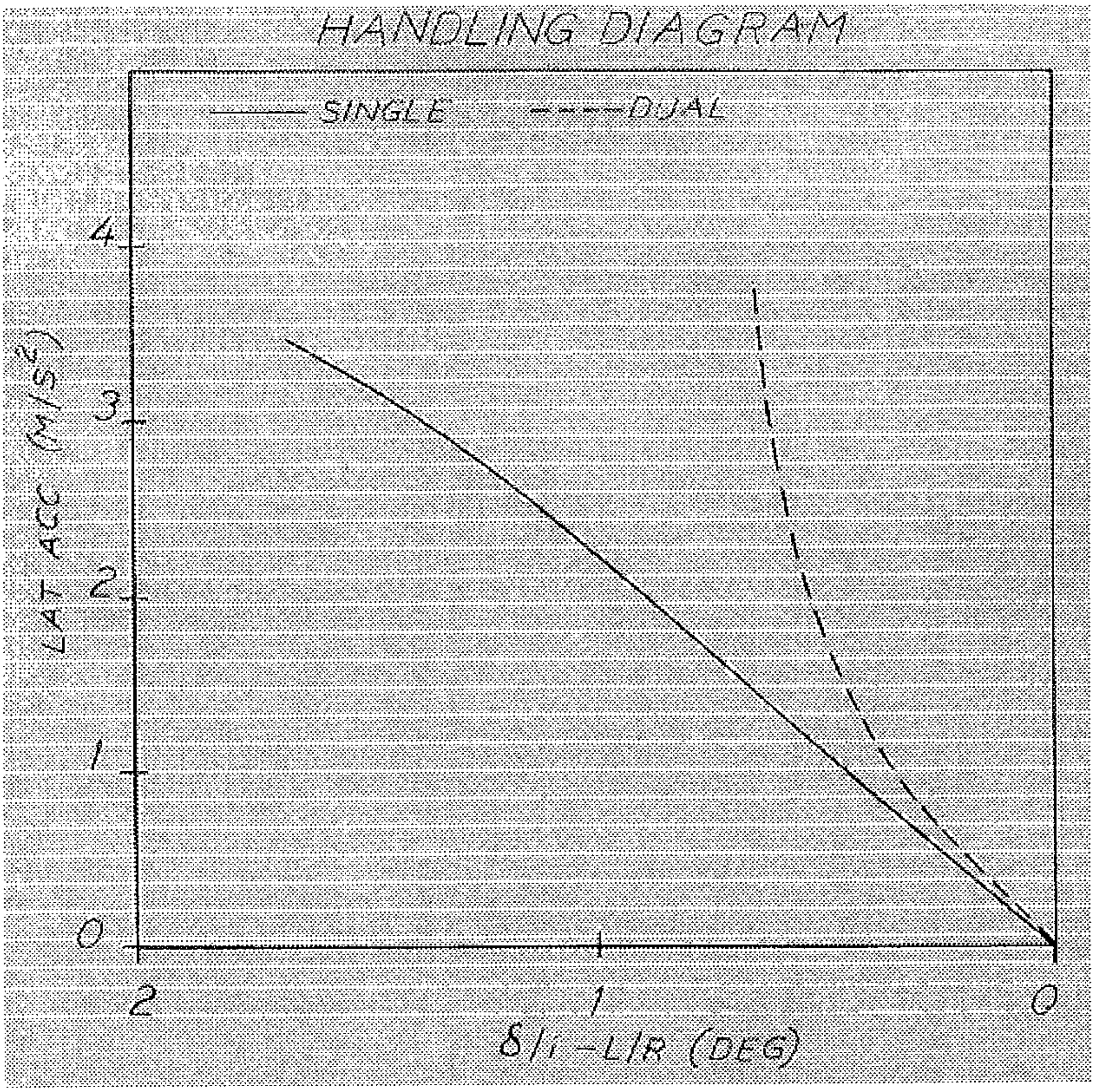

Figure 1. Comparison between steady state response characteristics

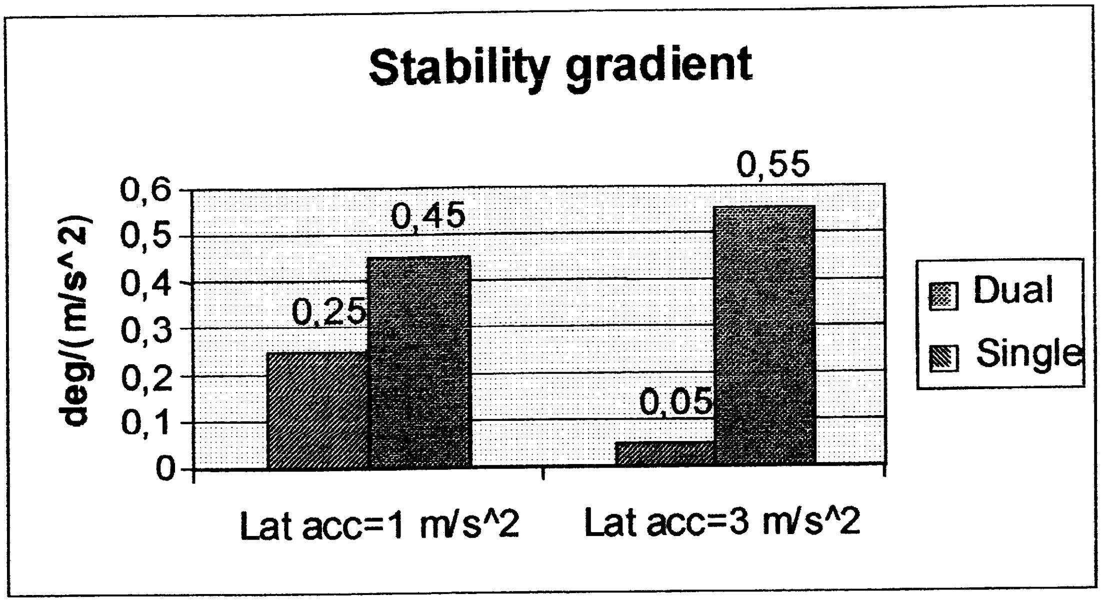

Figure 2. Stability gradient for the two tyre alternatives

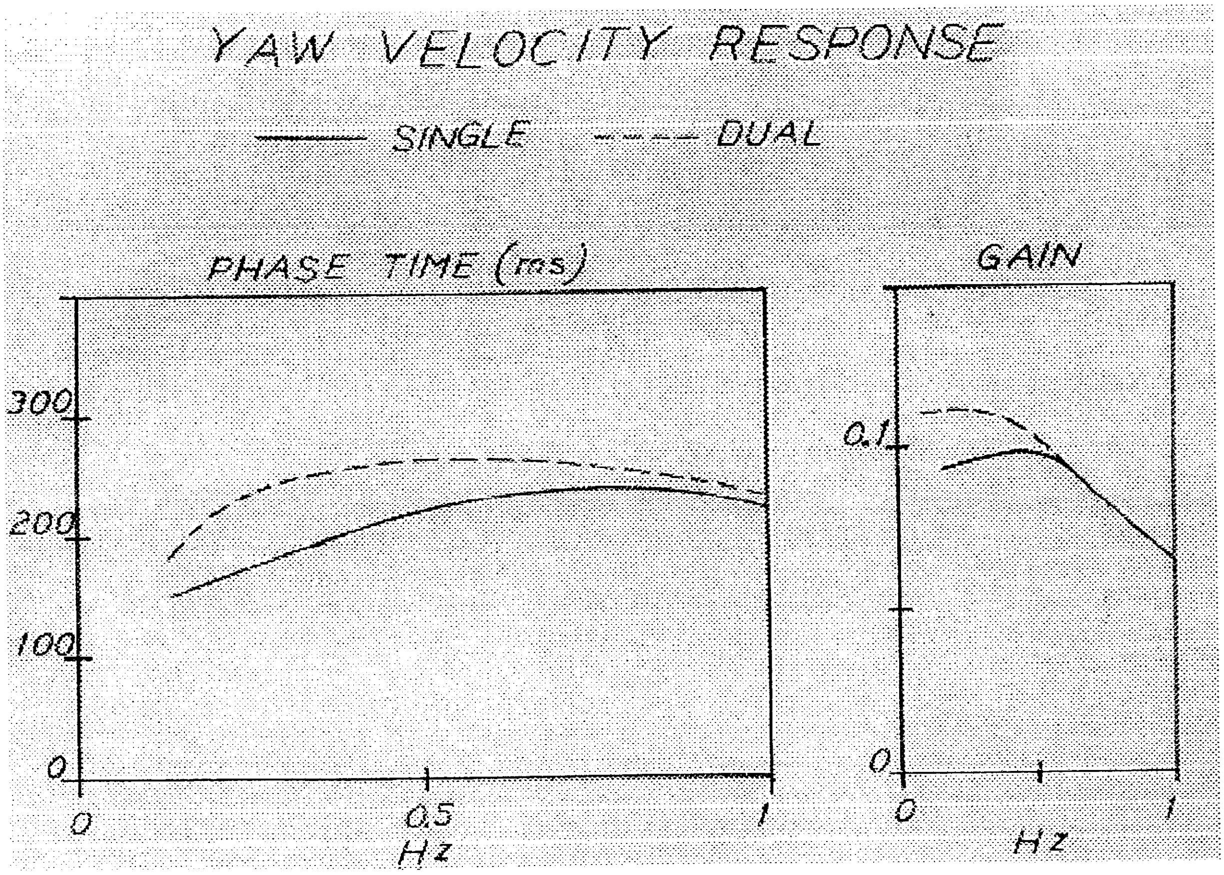

Figure 3. Comparison between transient response characteristics

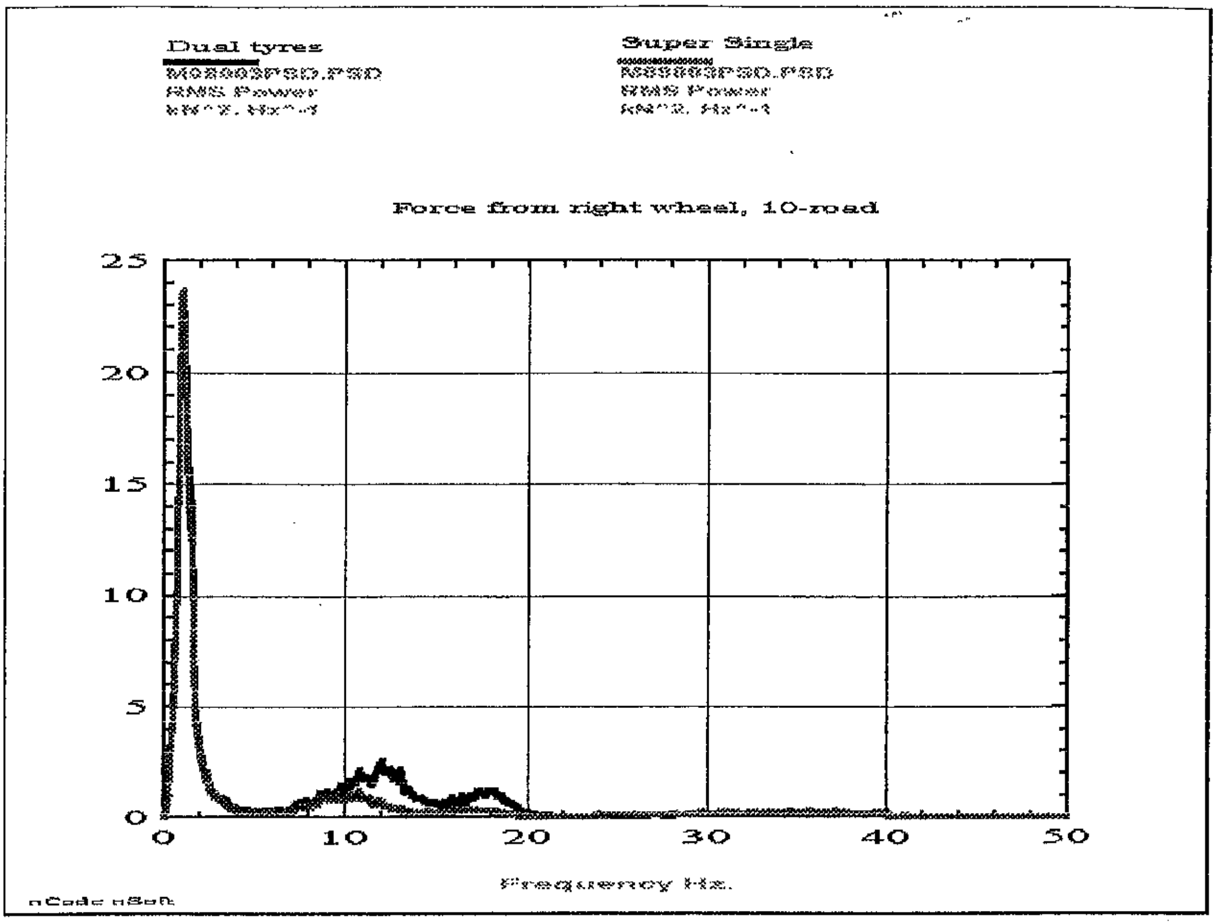

Figure 4. Autospectra for the dynamic wheel forces

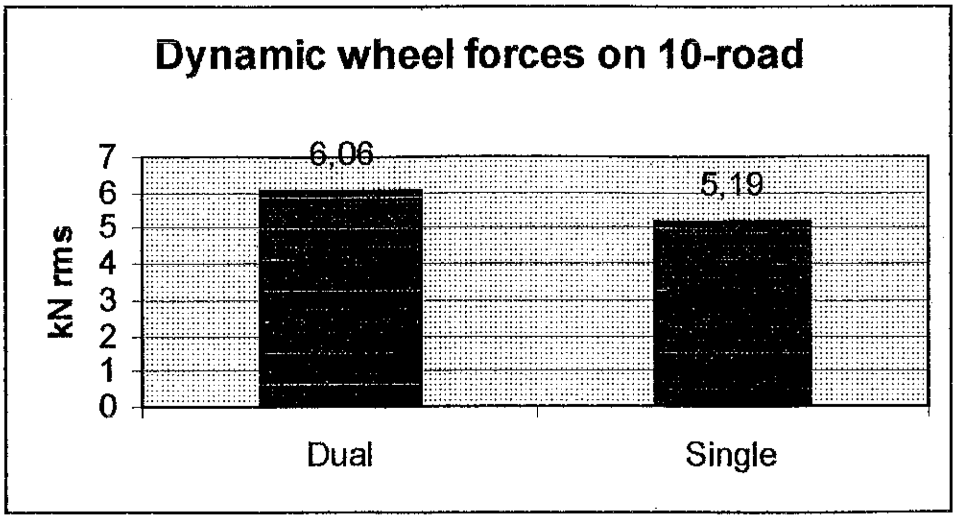

Figure 5. Comparison of dynamic wheel forces

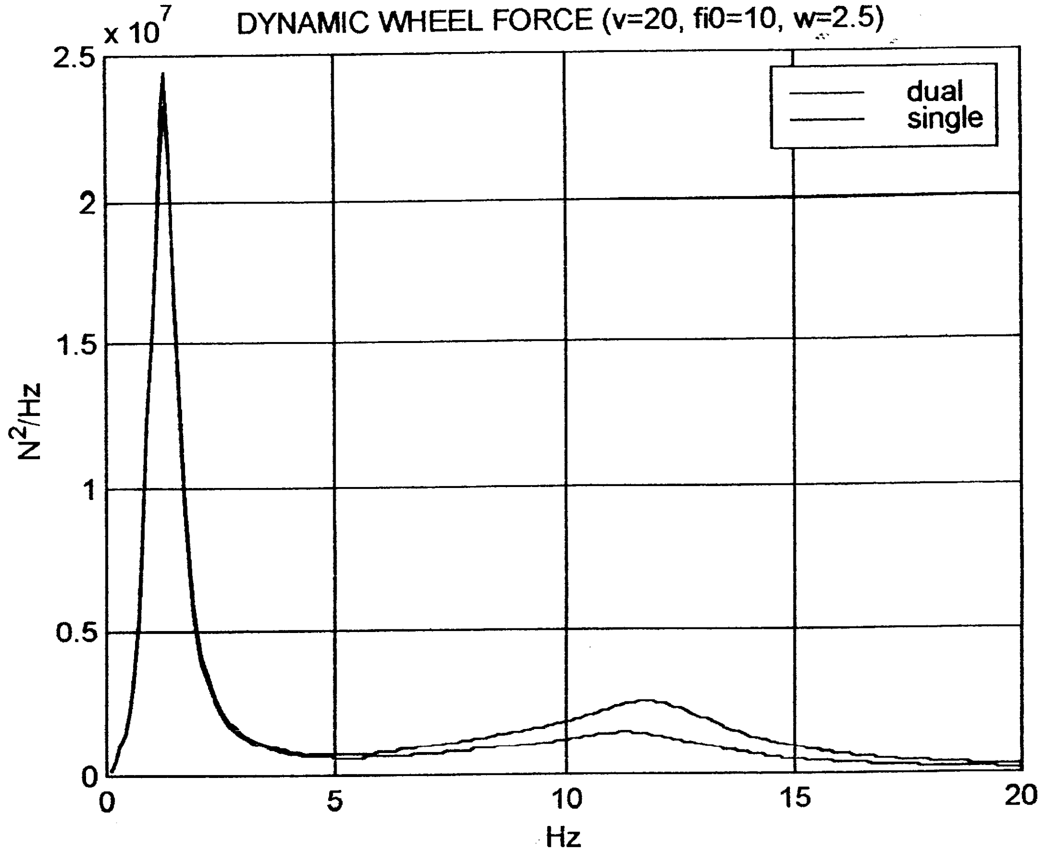

Figure 6. Autospectra from vehicle model