Overland Freight Transportation

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Much freight moves around the world in sea-going ships, and this is clearly the most economical method, but there are many parts of the world that are a long way from the nearest sea-port and where long distance overland transportation of heavy and bulky freight is essential. Here, the options are road or rail; I am ignoring air transportation, as this may be useful for perishable materials where time is a priority, but for such things as construction materials, mineral ores and containerised goods, surface transportation is really the only economic option.

Current heavy freight road transport costs and limitations are:

- 80 litres of diesel per 100 km for road trains, with a 120 tonnes gross weight, 64 tonnes of freight,
- or 26 litres per 100 km for articulated lorries, with a 44 tonnes gross weight and 26 tonnes of freight.

Thus road trains consume about 0.8 litres of fuel per tonne of freight per 100 km, and articulated lorries about 1.0 litres per tonne of freight per 100 km.

Road trains are limited to slopes of about 1:50, articulated lorries to 1:22. Road trains need motorway-style road junctions and cannot negotiate roundabouts, right-angle bends or traffic lights; they need a 30m radius to turn. Articulated lorries can negotiate most public roads even in towns and need a 13m radius. Some articulated lorries feature rear wheel steering and this reduces the minimum turn radius to 8m. Both types are heavily compromised by light surface snow, ice or mud, and during and after an unexpected storm, can cause roads to be blocked for hours. The limitations on slopes, snow and ice are entirely attributable to having power applied to only a small proportion of the wheels. Some experiments have been performed on road trains to provide rear-wheel steering on the individual trailers, but this seems to be a tricky problem.

For rail transport, the fuel consumption is about 0.4 litres of diesel per tonne of freight per 100 km, the maximum slope is 1:100 and the minimum turn radius is 45 m. However, freight trains carry a risk on twisty tracks if they are very long, as too much coupling tension can easily cause derailment, which is why very long trains have power cars distributed throughout the length of the train. Freight trains are compromised to a lesser degree by ice and snow, as the driven wheels always have a means of dropping sand onto the track.

This document proposes solutions to these problems.

For road haulage, the proposal is to use a diesel or gas turbine engine running at constant speed to generate electrical power. This is distributed to a motor of about 200 kW attached to each wheel, (where there are two or three tyres on the same side of the same axle, this is regarded as one wheel). Each wheel receives a control signal that defines the speed that the driver wants and this adjusts the power applied to the wheel; it also detects wheel-spin and corrects this. Thus every wheel on the road is used to propel the vehicle. Regenerative braking can be used to divert braking energy into batteries, (perhaps one for each wheel), which can be fed back into the wheel when reaccelerating. This will make little difference on long journeys using flat roads, but in a hilly, urban or congested situation, can save a significant amount of fuel. The effect of this on an articulated lorry or road train is to enable them to mount slopes of 1:8. In snow or ice they will have no more difficulty than the average 4x4 SUV with limited slip differentials and traction control, and may even do slightly better. In terms of power efficiency, the electrical system is about 2% better than mechanical gears and propeller shafts. The greatest fuel efficiency improvement, however, could come from the use of the techniques covered by another document: “Internal Combustion Engine Water Injection”, (see References).

By applying this technique to railway freight trains, with a 200 kW motor attached to each axle of every freight car, the steepest slope that can be handled will be increased to almost the theoretical limit for steel wheels on steel rails, about 1:32. The handling of snow and ice will also be improved but to a smaller degree than road vehicles. The cornering risk mentioned above is avoided by this system as the coupling tension can be monitored and the power to each axle adjusted accordingly.

The systems available for rear steering of articulated lorries have been well developed and do not need improvement. There is, however, a problem with road trains, if they find the intended road is blocked and they have to take a diversion along unsuitable roads. It can take four hours to turn the whole thing to face the opposite way. This problem can be solved if the whole road-train is double-ended, if each trailer can be steered and towed from either end.

Many holiday resorts have novelty land-trains for children to ride on. These can tow several carriages and remarkably, if you observe them turning a sharp bend, each carriage follows exactly the line of the previous one. This is achieved by having wheels that steer at each end of the carriage, the steering being controlled by the rigid tow-bar.

This principle can be applied to road-trains so that each trailer automatically follows in the previous one’s wheel-tracks with an accuracy better than 12%. The last trailer needs either to have its rear axle steering locked in the straight-ahead position or to have its steering mechanically linked to the steering at the other end. If the driver leaves a margin of about 15% around any obstructions, none of the trailers will experience any problem.

References:

“Internal Combustion Engine Water Injection”: John McCulloch, (available on: http://www.intint.co.uk/environ.html