A STUDY OF SUGAR INDUSTRY VEHICLE CONFIGURATIONS AND THE IMPACT OF RISKS AND OPPORTUNITIES ON HAULAGE COSTS

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Abstract

The sugar industry is made up of numerous hauliers using a wide variety of different tractor and truck configurations, many of which have outdated technology. Some of the reasons for this are differing business principles and historical tendencies. However, continuing in these practices may result in economic losses for those role players. It is therefore important that the cost of haulage associated with using different vehicle configurations is understood.

Together with rising input costs, current global economic situation, pending Consignee/ Consignor and 'Haulage Tractor' legislation, role players involved in the haulage of sugarcane need to be aware of the different vehicle configurations and the opportunities and risks that they face by using them.

This paper is a desktop study using TransSolve to demonstrate and compare the haulage costs of different vehicle configurations and combinations and the risks involved, such as the effect on changing parameters. However, numerous opportunities also exist, such as innovations to reduce tare and thereby increase payload on the haulage cost. The information obtained from this study can be used in the future to help role players decide on the vehicle configuration which would best suit their needs.

Keywords: sugarcane, vehicle configuration, haulage, risks, opportunities, haulage legislation

Introduction

Hauliers in the South African sugar industry face challenging times ahead and will need to operate as efficiently as possible to survive. It is therefore important that the cost of transport and the selection of the appropriate vehicle combinations are investigated and evaluated.

The industry uses an array of tractor and truck combinations, due to factors such as:

- Vehicles are used for different operations such as being loaded infield or from a zone.
- Haulage distances vary from short to long distances.
- Many emerging growers use older, less expensive configurations and systems.
- Some vehicles are older units which are paid off, do not have a high utilisation and will not be replaced for many years.
- Some hauliers choose the latest technology vehicles and strive for high utilisation.
- Growers' personal preferences.

There is also increasing pressure from a number of areas:

- Overload control measures and the inception of the Consignee/Consignor regulations.
- Self regulation, Road Traffic Management System (RTMS).
- Haulage tractor regulations.
- Increased input costs.

All of the above make it difficult for an operator to select the correct vehicle for his operation. The pressure of the aforementioned points motivated the authors to carry out a desktop study to investigate the cost of different vehicle combinations and the effects of changing parameters on the cost.

Resources and Methods

This paper involved certain of the current vehicle configurations, their performance compared with each other based on certain industry averages and a sensitivity analysis of these configurations to real industry risks and opportunities. TransSolve 2007, developed by Hellberg Transport Management (HTM, 2007), was used to generate and analyse the results and the effect of certain changes. Both the Sugar Logistics Improvement Programme (SLIP) and Road Traffic Management System (RTMS) databases and procedures were used to evaluate certain parameters of the vehicles.

Analysis

The following chapter explains how the benchmark figures were established and the effects of changes on the R/ton cost.

Assumptions and Inputs

A brief analysis of the current truck combinations in the SLIP and RTMS sugar database reveals that there are a few combinations which are popular. Firstly, a truck tractor can be coupled with a double axle semi-trailer, a triaxle semi-trailer or an interlink and semi-trailer. A rigid truck can haul on its own, or can be coupled with various pup trailers or, more commonly, a drawbar trailer. Most popular in the industry and making up over 85% of the truck combinations are the interlink and rigid and drawbar combinations (RTMS database), and these were therefore used in the investigation. Although not common in the sugar industry, the triaxle combination was also used in this investigation. The investigation did not involve agricultural tractor combinations.

The Transolve 2007 software was set up using the identical truck tractor and rigid truck for both the interlink and rigid and drawbar combinations. The smaller horsepower truck tractor, of the same make and model, was used in the triaxle combination. The trailers and bins were those in the software which had the lowest tare and therefore allowed the greatest payload. All the combinations were those which were available for purchase.

For each combination, the following parameters were entered into Transolve 2007:

The route was from Impala to Kaalrug in Mpumalanga and return. The return distance was 50.6 km, which was chosen because the average lead distance for the industry is 25 km. The route was relatively flat with altitude varying between 300 and 600 m above sea level, a difference of 300 m.

Loading took place at Kaalrug and offloading at Impala. A 10 minute excessive idling time was given.

The vehicle was assigned a maximum speed of 80 km/h loaded and unloaded. The coefficient of drag was set at 1.4, which is typical of a truck tractor or rigid truck with cane trailers. Each vehicle was set to operate in its green band rev range (rpm), as per the manufacturer's specification.

The result of this simulation was a trip-specific time, distance, average speed, fuel used and fuel consumption. The performance was used to complete the costing analysis.

Fixed costs included:

Annual, kilometres, tons, hours and trips were calculated by using a 190 day season broken down into three eight hour shifts. Loading time was based on the combination's individual payload and was assumed at:

- 1 hour for the rigid and drawbar.
- 57 minutes and 30 seconds for the interlink.
- 54 minutes for the triaxle.

Offloading was assumed to be 1 hour 20 minutes.

Finance was calculated using the cost of the truck as per the software in conjunction with the cost of trailers. It was assumed that:

- The interlink trailers totalled R700 000.
- The bin and drawbar trailer totalled R700 000.
- The triaxle semi-trailer totalled R475 000.

This price included an on-board weighing system. The finance option chosen was an instalment sale over 60 months at 15.5%. No residual value on the truck was used.

Crew cost was assumed at R2000 per driver per shift per week for 34 weeks. Insurance of the truck was calculated at 8% of the value, while insurance of the trailers and on board weighing system was calculated at 6% of the value. Licence fees were calculated at the current rate linked to KwaZulu-Natal. Other vehicle expenses included R450 per month for a GPS tracking system. Overhead costs were calculated at 10% of total fixed costs.

Variable costs included:

The fuel and lubrication costs which were linked to the litres/100 km specific to the trip at a rate of R9.03 per litre of diesel. This was linked to the annual kilometres travelled. Lubricants and top-up oil was calculated at 1% of the total fuel costs.

Tyres were calculated by using the cost of tyres and distance travelled as per the software for the vehicle. The trailer was assumed to have single tyres per each axle, costing R8 000 per tyre and travelling 60 000 km each. It was felt that this was a reasonable rate to use and would be used throughout the testing for consistency.

Maintenance was calculated by choosing:

- full maintenance with provision for premature failures.
- first service interval at 25 000 km, with a maximum distance of 1 050 000 km and/or 60 months.
- dividing the annual kilometers travelled by 12 to get a monthly kilometers travelled.
- a 60 month contract.

The result of this was a R/km rate for the vehicle, and the trailer maintenance was calculated by using a rate of R0.04/km per axle. The route had no tolls or need for special permits and no other vehicle expenses were added. The fixed and variable costs were calculated to give the total costs. The results were expressed as R/annum, R/km, R/ton, % of fixed and variable costs and % of total costs.

Benchmark results

Table 1 shows a breakdown of the results for the three vehicles on the chosen route.

Table 1. Breakdown of costs per combination.

Rigid and drawbar					
kW rating	324		Payload	34 204	
Annual kilometres	59 854		Annual hours	4560	
Annual tons	40 459		Annual trips	1183	
Travel time – return	1 h 31 min		Fuel used – return	30.7l	
Average speed	33.3 km/h		Fuel consumption	60.7l/100 km	
Fixed costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Finance	461 276.28	7.71	11.4	50.9	34.0
Crew	204 000.00	3.41	5.04	22.5	15.0
Insurance	119 541.41	2.00	2.95	13.2	8.8
Licence fees	24 639.00	0.41	0.61	2.7	1.8
Other vehicle expenses	5 400.00	0.09	0.13	0.6	0.4
Overheads	90 539.63	1.51	2.24	10.00	6.7
Subtotal	905 396.32	15.13	22.38	100.00	66.8
Variable costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Fuel and lubricants	331 462.24	5.54	8.19	73.5	24.4
Tyres	69 239.11	1.16	1.71	15.4	5.1
Maintenance	49 978.09	0.84	1.24	11.1	3.7
Subtotal	450 679.44	7.53	11.14	100	33.2
Total costs	1 356 075.76	22.66	33.52		100

Interlink					
kW rating	324		Payload	32746	
Annual kilometres	60 482		Annual hours	4560	
Annual tons	39 141		Annual trips	1195	
Travel time – return	1 h 31 min		Fuel used – return	31.71	
Average speed	33.2 km/h		Fuel consumption	62.71/100 km	
Fixed costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Finance	465 571.20	7.70	11.89	51.3	33.9
Crew	204 000.00	3.37	5.21	22.5	14.9
Insurance	120 791.33	2.00	3.09	13.3	8.8
Licence fees	20 835.00	0.34	0.53	2.3	1.5
Other vehicle expenses	5 400.00	0.09	0.14	0.6	0.4
Overheads	90 733.06	1.50	2.32	10.0	6.6
Subtotal	907 330.59	15.00	23.18	100.0	66.1
Variable costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Fuel and lubricants	345 586.17	5.71	8.83	74.2	25.2
Tyres	69 457.53	1.15	1.77	14.9	5.1
Maintenance	50 502.47	0.84	1.29	10.8	3.7
Subtotal	465 546.17	7.7	11.89	100.0	33.9
Total costs	1 372 876.76	22.7	35.08		100.0

Triaxle					
kW rating	286		Payload	30669	
Annual kilometres	61 777		Annual hours	4560	
Annual units	37 443		Annual trips	1221	
Travel time – return	1 h 30 min		Fuel used – return	27.31	
Average speed	33.7 km/h		Fuel consumption	53.91/100 km	
Fixed costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Finance	361 615.92	5.85	9.66	47.8	31.0
Crew	204 000.00	3.30	5.45	27.0	17.5
Insurance	95 263.06	1.54	2.54	12.6	8.2
Licence fees	14 418.00	0.23	0.39	1.9	1.2
Other vehicle expenses	5 400.00	0.09	0.14	0.7	0.5
Overheads	75 633.00	1.22	2.02	10.0	6.5
Subtotal	756 329.98	12.24	20.20	100.0	64.8
Variable costs	**R/annum**	**R/km**	**R/ton**	**% Fixed**	**% Total**
Fuel and Lubricants	303 573.27	4.91	8.11	74.0	26.0
Tyres	57 681.18	0.93	1.54	14.1	4.9
Maintenance	49 112.72	0.80	1.31	12.0	4.2
Sub Total	410 367.17	6.64	10.96	100.0	35.2
Total Costs	1 166 697.15	18.89	31.16		100.0

Table 2 shows a summary of the costs for the three vehicles. Although the rigid and drawbar and interlink combinations have a higher payload, they are 7.4% and 12.5% more expensive to operate respectively than the triaxle combination.

Table 2. Summary of the payloads and cost for each combination.

Combination	Rigid and drawbar	Interlink	Triaxle
Payload in kgs	34 204	32 746	30 669
R/ton	33.5	35.1	31.2

Effects of changes

Using the above results as the benchmark simulations for a particular route, certain changes can be made to show the effect of them on the R/tonne cost. These parameters can be broken down into 2 broad categories:

- Truck selection - those which should be investigated before choosing a vehicle and combination;
- Operations - those which the haulier has to deal with while operating the chosen vehicle and combination. Operation is then broken down into those in the control of the haulier such which route to use, and those out of the control of the haulier such as fuel.

Truck selection

The following parameters are those which the haulier should investigate before choosing a vehicle and combination.

Sezela route
The Kaalrug route was inland and relatively flat. To analyse whether location and topography could effect the R/ton cost of haulage a route in the Sezela region was investigated.

From Sezela to Braermar on the R612 and return. The return distance was 51.5 km and the altitude varied between 50 m and 450 m above sea level, the change in altitude being 400 km. Compared with the Impala to Kaalrug route, this route is on the coast.

The results show that operating the same vehicles on different routes can have an impact on the R/ton cost (Table 3).

Table 3: The impact of a different route on the cost of carting cane.

<table>
<tr><th colspan="2">Combination</th><th>Rigid and drawbar</th><th>Interlink</th><th>Triaxle</th></tr>
<tr><td colspan="2">Payload in kgs</td><td>34 204</td><td>32 746</td><td>30 669</td></tr>
<tr><td rowspan="2">R/ton</td><td>Benchmark</td><td>33.5</td><td>35.1</td><td>31.2</td></tr>
<tr><td>Sezela</td><td>31.6</td><td>33.2</td><td>29.2</td></tr>
</table>

Trip total
Although the industry average lead distance is roughly 25 km, (SLIP, 2008), some mill areas have higher average leads than others. Increasing the lead distance will increase the R/ton cost (Figure 1).

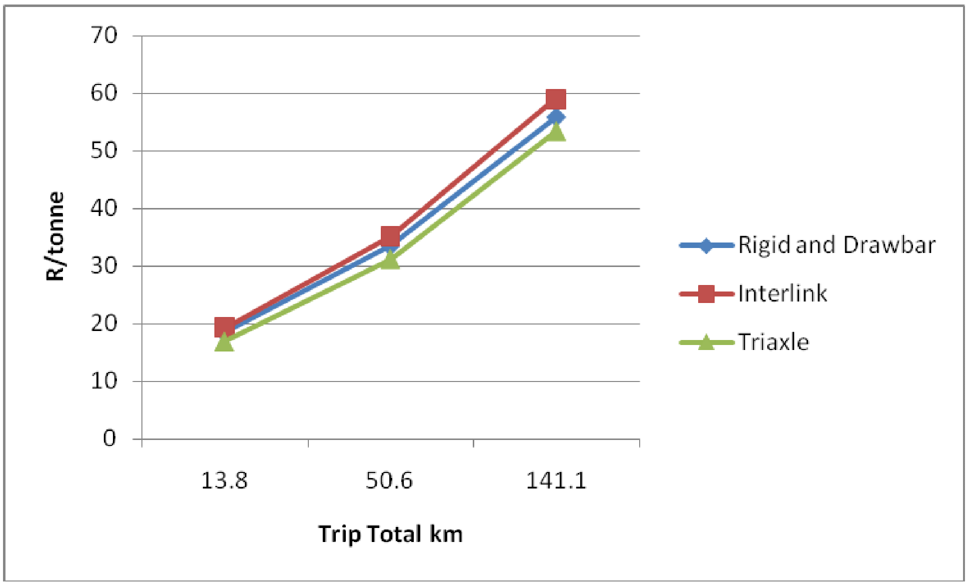

Figure 1. The effect of distance on the haulage cost of cane.

The graph shows that, at a shorter distance, the R/ton of the combinations does not differ greatly but, as the lead increases, so R/ton increases and the three combination costs never cross each other. In conclusion on the long and short trip total, the triaxle combination had the lowest R/ton cost.

Manufacturer
There are many makes and models of vehicles on offer to the haulier. Selling points for most hauliers are:

- Price
- Vehicle specifications
- After sales service and warranty
- Choosing a trusted and well known make
- User preferences.

Certain differences between the benchmark and the other manufacturer exist. Purchase prices vary, and therefore finance, insurance and licence fees vary. Even with the smallest difference in performance with regards to average speed, fuel used and litres per 100 km, the annual kilometers, tons and trips affect the variable cost of fuel, tyres and maintenance. The three combinations have been simulated using vehicles from a different manufacturer (Table 4).

Table 4. Differences in cost for different makes of vehicles for different combinations on the same route.

	Rigid and drawbar		Interlink		Triaxle	
	Benchmark	Other Manufacturer	Benchmark	Other Manufacturer	Benchmark	Other Manufacturer
Horsepower	460	480	460	480	390	400
Payload	34 204	33 330	32 746	32 430	30 669	31 717
R/ton	33.5	36.9	35.1	38.4	31.2	33.8

Power
When choosing a vehicle and considering the power to mass ratio, the buyer may choose between a vehicle with just enough power to haul the desired gross mass, and a vehicle with additional power, an advantage of which would be speed up hills.

The triaxle combination has been simulated with a 460 horsepower on both routes. These results will be compared with those of the triaxle with a 390 horsepower horse. The two truck tractors were of the same make and range (Table 5).

Table 5. Costs of a triaxle vehicle with two power ratings.

Triaxle			
Horsepower		390	460
Payload in kgs		30 669	30 652
R/ton	Benchmark	31.2	32.9
	Sezela	29.2	30.6

On both routes the R/ton cost was less using the 390 horse power vehicle, however careful consideration needs to be taken as using a vehicle with a low horse power may limit resale and the use of the vehicle during the off-crop.

Increase the payload
The only way to increase the payload legally, is to reduce the tare mass of the combinations. The simulations which have been done have used vehicles and trailers which can at present be purchased. Changing the tare of the combination will involve a redesign of these vehicles and trailers, and could be costly. The interlink combination has been coupled with a different set of trailers which reduced the payload by 400 kgs. The result was that the R/ton cost increased from 35.08 to 35.52. Therefore, the higher the payload, the lower the R/ton cost.

Driving style changes
The simulations assumed that the vehicle was driven economically. This can be achieved if one has well trained drivers and uses a vehicle management system to incentivise drivers. In reality, the fuel consumption per 100 km can be as much as 15% higher (personal communication[1]) and in such cases the R/ton cost of each vehicle combination increases

[1] Mr Ken Bailey, Compass FM (2008).

considerably, as shown in Table 6. A 15% increase in fuel consumption resulted in over R1.00 increase in R/ton for each combination.

Table 6. Impact of driver driving style on haulage costs.

Scenario	Rigid and drawbar	Interlink	Triaxle
Benchmark	33.5	35.1	31.2
Poor driving style	34.8	36.4	32.4

Excessive idle time
Each simulation was done with a three minute engine idle time at engine start and one minute idle time at engine stop, with a 10 minute idle time during the trip. The 10 minute idle time was re-set at 0 minutes and the R/ton cost decreased substantially on each combination. Table 7 shows that 10 minutes' worth of vehicle idle time is worth about R1/ton on each combination.

Table 7. Increase in cost due to an increase in idle time.

Scenario	Rigid and drawbar	Interlink	Triaxle
Benchmark	33.5	35.1	31.2
No excessive idling	32.5	34.0	30.2

Operational

Certain parameters are out of the control of the haulier but are real risks, and the effect thereof needs to be noted.

Fuel price
With the price of crude oil and the exchange rate as unstable as they are currently, the varying price of fuel is likely to have an impact on the R/ton cost. The benchmark simulations used a fuel price of R9.03. The effect of an increase in price to R10.03/L and a decrease in the price to R8.03/L is shown in Table 8.

Table 8. Impact of fuel cost on the cost of haulage.

Combination		Rigid and drawbar	Interlink	Triaxle
R/ton	R8.03/L	32.6	34.1	30.3
	R9.03/L	33.5	35.1	31.2
	R10.03/L	34.4	36.1	32.1

The rigid and drawbar, which has the highest payload, is least susceptible to an increase in the fuel price, while the triaxle is the most susceptible.

Queue time at the mill

As queue time increases the total trip time increases, and fewer trips can be completed, resulting in less tonnage being moved. The benchmark simulation uses 1 hour 20 minutes as the mill turnaround time. This is roughly the SLIP industry average. However, there are mills which have turnaround times as high as two hours, such as Amatikulu mill, and others such as Darnall, lower than 40 minutes. The effect of this is shown below in Table 9. Each vehicle combination offloading time is increased and decreased by 40 minutes around the Benchmark. The increase in queue time from 40 min to 2 h results in a 25% increase in cost is all three cases.

Table 9. The impact of queue time at the mill on the cost of haulage.

Combination			Rigid and drawbar	Interlink	Triaxle
Payload in kgs			34 204	32 746	30 669
Turnaround time	40 mins	R/ton	29.7	31.1	27.7
	1 h 20 mins		33.5	35.1	31.2
	2 hours		37.3	39.1	34.7

Interest rate

The interest rate may change and will have an effect on the monthly instalments, which will have an effect on the R/ton cost. The interest rate has been increased and decreased by 0.5% to show its effect on R/ton. The results in Table 10 show that the change in the interest rate of 0.5% has between 12 and 15 cents impact on the R/ton depending on the vehicle combination.

Table 10. The impact of interest change on the cost of haulage.

Scenario	Rigid and drawbar	Interlink	Triaxle
Interest rate decrease	33.4	34.9	31
Benchmark	33.5	35.1	31.2
Interest rate increase	33.7	35.2	31.3

Vehicle price increases

Using an inflation rate of 5%, which is within South Africa's inflation targeting, it is assumed that the price of the vehicles being used should increase at this rate. If one vehicle needs to be replaced one year later, the vehicle price will have inflated by 5%. However, the current inflation rate for vehicle prices is around 12% - therefore the situation could be worse for the haulier. Table 11 shows the effect of this scenario.

Table 11. The impact of inflation of purchase price on the cost of haulage.

Scenario	Rigid and drawbar	Interlink	Triaxle
Benchmark	33.5	35.1	31.2
Price increase - 5%	34	35.6	31.6
Price increase - 12%	34.6	36.2	32.2

A haulier purchasing a certain fleet and needing to replace the vehicles must be aware of the cost implications of inflation on R/ton.

The vehicle is used during off-crop

By using combinations such as the interlink and the triaxle, there is an opportunity to use the truck-tractor with a different set of trailers during the off–crop, to haul other products. It is difficult to do this with the rigid truck as the bin is fairly permanent and sugar-specific. This means that certain fixed costs could be shared between the sugarcane haulage and the ‘other product’ haulage. Assuming that one can use the vehicle for an extra 101 days per year, Table 12 shows that the cost can be reduced by R7.90 and R6.90 for the interlink and triaxle respectively.

Table 12. The impact of using vehicles in the off crop and increasing the utilisation by 101 days.

<table>
<tr><th colspan="3">Combination</th><th>Interlink</th><th>Triaxle</th></tr>
<tr><td rowspan="2">Working days</td><td>190</td><td rowspan="2">R/ton</td><td>35.1</td><td>31.2</td></tr>
<tr><td>291</td><td>27.2</td><td>24.3</td></tr>
</table>

The above results have been collated in Table 13.

Best and worst case

From the above results there are countless scenarios which can be evaluated. However, the authors choose to evaluate a best and worst case scenario for each combination that should show the impact of more than one parameter on R/ton.

The combinations that were simulated in a best case scenario:

- the benchmark vehicle
- the truck tractor being allowed to operate in the off crop
- fuel consumption at the efficient benchmark rate
- excessive idle time was null
- the queue time at the mill was 40 minutes.

The combinations were then simulated at a worst case scenario:

- using the Other Manufacturer
- the vehicle was not used in the off crop
- fuel consumption was increased by 15%
- excessive idle time was 10 minutes
- the queue time at the mill was 2 hours.

Table 13. Summary of the effect of the changing parameters on the R/ton cost.

Parameter	Rigid and drawbar	Interlink	Triaxle
Benchmark (Kaalrug)	33.5	35.1	31.2
Truck selection			
Sezela route	31.6	33.2	29.2
Trip Total			
13.8 km	18.5	19.2	16.9
141.1 km	55.9	59.1	53.3
Other manufacturer	36.9	38.4	33.8
Power	N/A	N/A	32.9
Payload	N/A	35.5	N/A
Off-crop	N/A	27.2	24.3
Residual value	30.7	31.8	28.2
Operational			
Controlled			
Speed – 60 km/h	33.1	34.7	30.8
Driving style	34.8	36.4	32.4
Excess idling	32.5	34.0	30.2
Uncontrolled			
Queue time			
Increase by 40 min	37.3	39.1	34.7
Decrease by 40 min	29.7	31.1	27.7
Fuel Price			
Increase by R1/L	34.4	36.1	32.1
Decrease by R1/L	32.6	34.1	30.3
Interest rate			
Increase by 0.5%	33.7	35.2	31.3
Decrease by 0.5%	33.4	34.9	31
Price Increase			
By 5%	34	35.6	31.6
By 12%	34.6	36.2	32.2

The truck-tractors were given a 50% residual value and the rigid was given a residual value 45% of the new truck price. The results are shown in Table 14.

Table 14. The transport costs for the worst and best case scenario.

Scenario	Rigid and drawbar	Interlink	Triaxle
Best case	26.5	22.2	19.9
Benchmark	33.5	35.1	31.2
Worst case	38.1	39.1	34.4

The results reveal that minor changes to the operation and type of combination can result in large cost differences. The percentage increase in cost from the best to the worst case scenario are 44, 76 and 73 for the rigid and drawbar, interlink and triaxle, respectively.

Other factors to consider

The above results have shown the impact of changing the value of parameters on the combination haulage costs in R/ton. However, there are other factors which need to be considered. The practicality of using certain combinations in the industry needs to be questioned. For example:

Bulk density of cane and the load volume of the combinations
Depending on climate, season and variety of cane, the density can vary between 250 and 450 kg/m^3. The volumes of the different combinations vary substantially, and typical values are shown in Table 15.

Table 15. Payload, load volume and mass per unit volume available for various vehicle combinations.

Combination	Rigid and drawbar	Interlink	Triaxle
Payload in kgs	34 204	32 746	30 669
Load volume in m^3	108	117	94
Available mass per unit volume, kg/m^3	317	280	326

Because the interlink combination has the largest load volume available and therefore the lowest kg/m^3, it is efficient for low density and lodged cane. The vehicle regulations amended in 1999 enable the increase in dimensions of the triaxle to values above those normally used in the sugar industry and those simulated above. Therefore more volume could be achieved in a triaxle if necessary to produce a 'long' triaxle.

The 'long' triaxle
The amended regulations which allow longer semi-trailers opened the door for a longer triaxle, resulting in an increased payload.

Research into the dimensions of the triaxle combination allow an even more competitive rate (R/ton) than the rigid and drawbar and interlink combinations. However, there are factors to be considered with regards to a long triaxle, namely:

- the spiller may not be able to lift 31 tons out of one trailer
- the spiller table may not be as long as the trailer
- the triaxle may be less stable and less manoeuvrable.

It can be seen that one has to consider many factors when choosing a transport vehicle. However, the results show that the triaxle operates at the lowest R/ton and should be considered by hauliers when investigating different combinations.

Traction

Depending on the terrain of the mill area, hauliers may need a combination which guarantees good traction, by having as much weight on the drive axles as possible. Hauliers tend to choose rigid trucks when they require traction, particularly for infield operations. Transolve 2007 has schematics of the loading on each set of axles shown in Table 16.

Table 16. The loaded mass on the drive wheels for various vehicle combinations (Transolve, 2007).

Combination	Rigid and drawbar	Interlink	Triaxle
Mass on the drive axles	18 000 kg	16 333 kg	17 999 kg

The results show that both the rigid and drawbar and triaxle combinations maximise the mass on the drive axle. Because the triaxle gross mass is lower than the rigid and drawbar it could be assumed that the triaxle would have the better traction of the two combinations because, in any given situation, it would have less rolling resistance to overcome. The interlink does not have this advantage.

In the case where these combinations would need to stop, the triaxle may have an advantage over the other two combinations, as it maximises the mass on the drive axles and has less gross mass to 'stop'.

Conclusion

The results show that there are many different aspects which hauliers should take into account when deciding which truck and combination to use. They should use a sophisticated model, such as Transolve 2007, to help them analyze each option and the impact of each factor on the haulage cost R/ton.

However, the paper has shown that, provided the triaxle can achieve the desired payload, it is the most cost effective combination to operate in comparison to the rigid and drawbar and interlink. Because the triaxle has the lowest payload, it is the most sensitive to changes in the conditions. However, the relative impact of these changes on the R/ton is fairly small. Certain factors such as trailer volumes and spilling capacity at the mill would need to be investigated further before choosing to operate the 'long' triaxle.

From the investigation it can be seen that the interlink combination is the most expensive vehicle to operate, even at the high payload. The results also show that if hauliers consider all the factors affecting their operation and make considered decisions, they can reduce the cost of haulage significantly. Finally, it is recommended that hauliers seek professional advice when making a decision on the vehicle and combination to use for specific applications.

REFERENCES

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