The Use of Low Ground Pressure Vehicles for Timber Extraction on Forest and Weak Public Roads

The Highland Timber Transport Group

Chairman: Frank MacCulloch CEng MICE — September 2008

CONTENTS

The role of the Highland Timber Transport Group

The Highland Timber Transport Group (HTTG) is a voluntary partnership of public and private sector organisations with a common interest in resolving timber transport issues in the Highlands of Scotland. The group acts to promote solutions to timber transport problems and it is with this aim that it has undertaken this report.

Acknowledgements

This report relies heavily on information and assistance from a number of individuals who have been associated with the development of the use of the Low Ground Pressure trailers developed by JST Services for timber extraction.

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Introduction

Over the last six years JST Services of Ayr have developed a range of Low Ground Pressure (LGP) multi wheel trailers for use in timber extraction. They have now been used in a number of public and private sector forests and have successfully taken out over 500,000 tonnes of timber. The purpose of this report is to give an overview of the issues surrounding their use.

The report has been commissioned by Forest Enterprise with a view to disseminating the knowledge and experience gained so far. It draws on background research, site visits and information gained from meetings and discussions with those involved at first hand.

Background

As timber production expands so does the need to go deeper into forests, with round trips in-forest of 20km now not uncommon. This has brought timber transport into renewed focus as the difficulties and cost of extracting the product to market are major constraints in the supply chain. To this can be added increasing pressure to avoid communities and use long in-forest links to avoid public roads wherever possible.

The first section of the journey to market is usually the most problematic. Many situations arise where local public roads linking to the forest are simply incapable of carrying the standard 44 tonne articulated timber truck and it may be some distance to the nearest Agreed Route or other outlet.

In the forest itself, engineers and managers have to take difficult decisions about the extent of investment in roading, which ultimately becomes a cost on the product. With timber being a low margin commodity subject to international competition it is inevitable that these costs come under scrutiny.

Illustration 1: Soft forest road trafficked by JST tractor would normally be impassable

Arising from these considerations a number of projects have been taking place in recent years with a view to cutting costs over these critical sections of road. Some have sought to get a better understanding of the failure mechanisms of forest roads under heavy traffic, such as the Roads under Timber Traffic (RUTT) project in Dumfries and Galloway. Others have concentrated on the management of weak public roads used by timber traffic such as the B871 in Sutherland, where information has been shared under the international ROADEX programme. The common aim of such projects is to work out how best to keep road construction and maintenance costs as low as possible, whilst at the same time preserving reasonable and safe passage for vehicles.

Another angle from which to tackle this problem is to concentrate on the vehicle itself, to make it more "road friendly" and reduce its damaging impact. John Scott of JST Services has taken this step and invested heavily in LGP multi wheel trailers and towing plant. This report concentrates on the recent experience in this field.

Vehicle design: An inevitable compromise

Road-going trucks are known to suffer increased costs when used on forest roads, anecdotally at least a 50% increase in the rate per mile. This is closely related to the quality of the forest road, its geometry (gradients/bends etc), the standard of maintenance and the extent to which it deteriorates under use.

The interaction between the road and vehicle is a highly complex one involving a wide range of variables. Whilst it can readily be appreciated that a poor road can easily damage a vehicle it is less intuitive that poorly designed or maintained vehicles can, and do, seriously damage the road.

Some examples of the many variables that come into play in this complex equation are:

- Vehicle total load
- Individual axle load
- Individual wheel loads
- Suspension characteristics
- Speed of travel
- The roughness of the road
- The strength of the road pavement and soil foundation
- Prevailing and recent weather conditions

With so many variables it is inevitable that vehicle design has to be a compromise between competing requirements, with cost high up the list. In the same way as there are no perfect vehicles, perfect roads are rarely found because in practice they are unaffordable.

This is highly relevant to the timber industry particularly as hauls get longer. Standard road-going trucks are optimised for driving on well maintained public roads, not for long distance running on gravel roads constructed and maintained at minimum cost.

Illustration 2: Typical road-going artic loading in forest

An example of this need for compromise can be seen in the development of trailers equipped with Super Single tyres in recent years. This evolved from international negotiation to seek European standard for truck design that would improve safety and efficiency over the more traditional twin wheel options. The increased cost of road maintenance arising from the more concentrated wheel loadings under super singles was well understood at the time. However at strategic national level this was only one factor and it had to be weighed against the benefits of improved safety and other savings. As a result super single trailers have become the norm, in the timber industry as elsewhere.

Unfortunately at a local level things can be seen differently. On well engineered national roads the increased wheel loadings are dispersed through several thick layers of asphalt. However on a fragile side road with little or no surfacing the effect of the loading and its application nearer to the road edge can have major implications. To date much of the evidence is anecdotal but theory supports the contention that super singles are highly damaging to the sort of fragile roads that serve many rural forests. As a result a number of Roads Authorities in Scotland are moving to encourage wider use of less damaging vehicles for timber extraction on fragile Consultation Routes.

Towards More Road Friendly Vehicles

The term “Low Ground Pressure Vehicle” is commonly used to refer to lightweight, tracked or balloon tyred vehicles capable of travelling across peatlands and other soft areas. However it can be applied to any vehicle designed to spread its load over the largest possible area and that is the definition assumed in this report.

To understand the damaging effect of trucks on a road it is best to concentrate on the point where the load is transferred from the vehicle to the road ie the tyre/road surface interface. Factors to consider are:

- The bigger the area of tyre touching the road (its “footprint”) the lower will be the surface pressure on the road
- The lower the pressure in the tyre the bigger its footprint will be
- The greater the number of wheels the lower will be the load per wheel
- The greater the distance tyres are apart the more the load will be spread

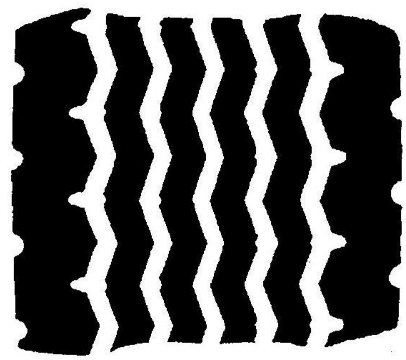


Illustration 3: Typical tyre footprint

At its simplest and in summary a road friendly timber truck will have many widely dispersed wheels running with soft tyres. That is the intention of the multi wheel trailers developed by JST: to spread the load across the full roadway rather than concentrate it all at the edges.

The key advantage from this arrangement should be lower roading costs in terms of both construction and maintenance. The downside is the higher purchase and maintenance cost arising from complex multi wheel arrangements and “one off” specialised vehicles.

Development of the JST Vehicles

The JST multi wheel trailer system has evolved over the last five years using practical experience based on live forest use. Two types of configuration in use in use at a number of locations and have been included in this report:

- Volvo FM480 truck plus LGP trailer, self loading (gross weight 80 tonne). This configuration is intended for dedicated in-forest service.
- Case Magnum MX255 tractor plus LGP trailers, single or in tandem (gross weight 35-50tonne), capable of operation in-forest or nearby on weak public roads

Illustration 4: The Volvo truck and trailer laden at Aberfoyle

During the development phase JST used Scammell 6x6 before changing to Terberg 8x8. Unfortunately reliability proved to be an ongoing issue with both these units. The requirement to operate for long periods off the public road in harsh forest conditions is hard on any vehicle. Whilst a road-going truck can return to base at night to be washed or serviced it is much more difficult to maintain a specialist vehicle in-forest. A move to Volvo FM480 6x6 units appears to have overcome these problems and they are operating satisfactorily in service.

Illustration 5: A rear view of the King trailer. Note the articulation and position of the wheels

The LGP trailer towed behind the truck has also been developed through experience in the field. Early suspension problems caused by running on rutted and heavily cambered roads have driven modification of the design. The current 4 axle trailer is manufactured by King and is rated at 55tonne gross, with the front rotating bogie having four sets of twin wheels on two axles. An interesting design feature is that the rear bogie wheels are inset by 150mm and do not therefore run in the tracks of those immediately on front.

Illustration 6: King trailer showing wheel arrangement. Note inset of bogie rear wheels

At the rear there are a further 8 wheels on two axles. This time the wheels are widely dispersed on a walking beam suspension arrangement, providing a high degree of articulation and a spread of load across the full roadway width.

Illustration 7: A Case Tractor operating in difficult conditions

In parallel with the above JST have developed LGP trailers to be towed by Case MX255 tractors. Manufactured by McAuley these have a two axle 8 wheel arrangement similar to the rear wheels of the Volvo trailer. These trailers are plated at 20tonne and can be hauled singly or in tandem. Being much shorter and lighter than the full Volvo units these are better suited to short/medium hauls on weak forest or public roads. They are not equipped with cranes requiring offloading facilities at either end

Illustration 8: View of McCauley trailer showing balance beam pivot. Note low tyre pressure

In order to spread the load and reduce ground pressure all the tyres are run at reduced pressure, normally 60psi. As described above this increases the tyre footprint compared to normal trucks running at 100psi+.

The following tables show the tyre arrangements in use. It can be seen that the Volvo unit has 26 wheels and the Case unit 12, compared to a regular 44 tonne super single unit that has 14.

Trailer Rear		Trailer Bogie		Volvo Truck		
Rear						Front
365x65R22.5	365x65R22.5	295/80R22.5	295/80R22.5	13R22.5	13R22.5	445x65R22.5
4No	4No	4No	4No	4No	4No	2No
Tyre pressure 60psi						

Tyre arrangement Volvo unit

Trailer		Tractor	
Rear	Front	Rear	Front
385x65 R22.5	385x65xR22.5	710x70xR42	540x65xR34
4No	4No	2No	2No
Tyre pressure 60psi			

Tyre arrangement Case unit

Equipment and Logistics

In 2008 the JST LGP fleet comprised:

Tow units	Number	Trailers	Number
Volvo FM12	2	King	2
Volvo FM12	2	JST	2
Case MX255	4	McCauley	4
Terregator	1	JST	1

The Volvo is taxed as a Special Vehicle and is licensed to travel on the road to and from site but not to carry timber on the road. It can run on Rebated Fuel in the forest. Given the logistics of the operation, including the need to set up adequate fuel supplies and other consumables to be available in the forest, the Volvo unit is very much aimed at large volume activity for a sustained period.

By comparison the Case units are licensed as agricultural vehicles and can be driven on the road using Rebated Fuel where exempted. In reality, except for short road journeys to site, they will normally be shipped by low loader as being more cost effective. They are a more flexible tool than the Volvo and aimed at different situations.

The Terregator is a recent addition to the fleet, providing another tool to complement the Volvo and Case units. In purpose it fits between the latter units having high capacity but also high traction. As a recent acquisition it has not been studied as part of this report.

TECHNICAL ISSUES

In terms of their impact on the road the JST vehicles differ from conventional trucks in two important aspects

- Wheel and Axle Loadings
- Their size and configuration and resulting swept path

Arrangements were made with JST Services to weigh typical vehicles and carry out a swept path analysis. The procedure and results are described in the following sections.

Wheel and Axle Loadings

In order to assess typical "in service" static loadings on the road structure the opportunity was taken to weigh two laden vehicles using portable weigh pads. The pads used were Haenni Type WL 103 rated at 10t maximum. These were constructed of an aluminium plate sandwich containing liquid filled tubes that measure the compression, converting the result to read out weight in Kg on a digital scale. Temperature effects are automatically compensated.

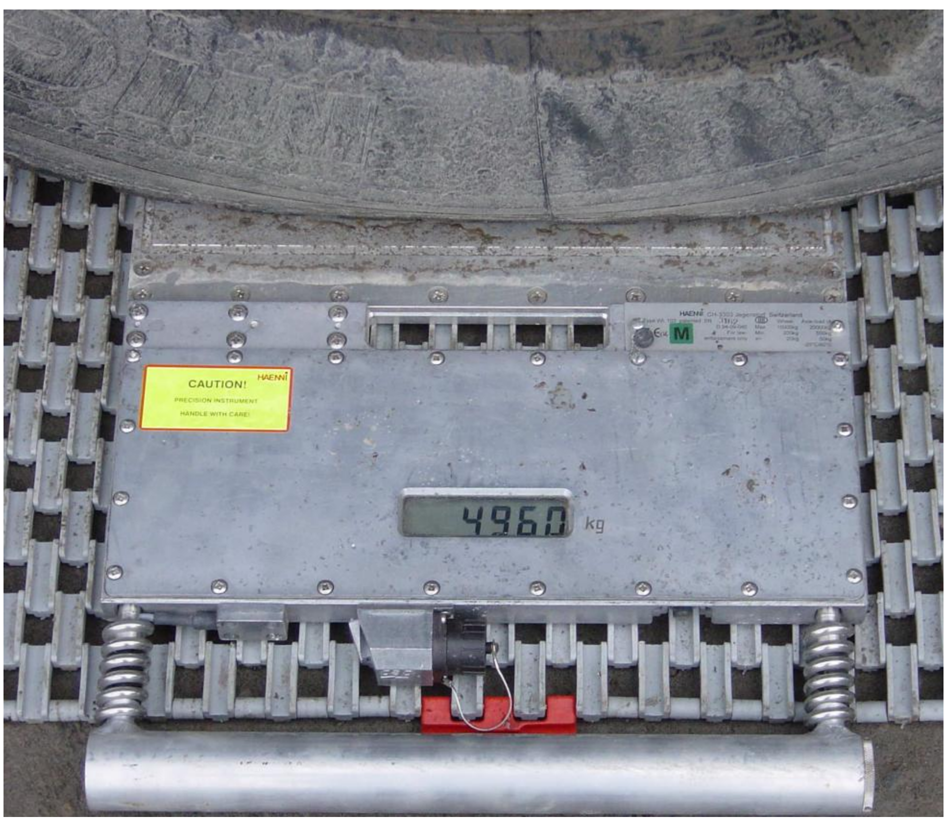


Illustration 9: Picture showing weigh pad under load. Note "soft" tyre at 60psi

Volvo and trailer

A JST Volvo 6x6 unit operating in Aberfoyle forest was the first to be tested. A level section of forest road was selected to be within the 5% crossfall/gradient specified. Each wheel was then weighed separately, two at a time, using a pad under each. An exception was made with the twin wheels which were measured as pairs together on a single pad. This reasonably assumes that the load on each of a pair of bolted twin wheels is roughly equal, unless extraneous factors such as differences in tyre pressure, road camber, tyre type etc come into play, these being beyond the immediate scope of the exercise.

Illustration 10: Weighing King trailer wheels in pairs using mats to compensate for pad thickness

	Trailer				Truck		
	Rear		Bogie				Front
	Axle 7	Axle 6	Axle 5	Axle 4	Axle 3	Axle 2	Axle 1
Nearside	3200	3360		4700*	6440*	6620*	4580
	3420	3380	5440*				
	3340	3100	4960*				
Offside	3200	3500		3660*	5960*	6340*	4720
Axle total	*13160*	*13340*	*10400*	*8360*	*12400*	*12960*	*9300*
Gross	*45.2t*				*34.6t*		
Tare	*15.2t*				*19.1t*		
Payload	*30.0t*				*15.5t*		

Volvo Truck and trailer: Measured Loads (kg)
*Note: Loads marked * are spread over twin wheels*

Case Tractor and trailer

A Case tractor and trailer unit was fully laden at the JST yard at Ayr and a similar exercise carried out with the results as detailed below:

	Trailer		Tractor	
	Rear			Front
	Axle 4	Axle 3	Axle 2	Axle 1
Nearside	2920	2560	4060	1900
	2480	2840		
	3480	3020		
Offside	3260	3740	4440	1940
Axle total	*12140*	*12160*	*8500*	*3840*
Gross	*36.6t*			
Tare	*17.5t*			
Payload	*19.1t*			

Case Tractor and trailer: Measured Loads (kg)

Knowing the unladen weight of the trailer (5500kg) it can be computed that the downward load on the tractor drawbar is 340kg.

Conveniently it was possible to put this tractor and trailer across the JST weighbridge giving a total weight of 36.800t compared to the sum of the separately weighed wheels of 36.640t. This difference of only 0.4% gave confidence in the weighing procedure and equipment.

Discussion of Results

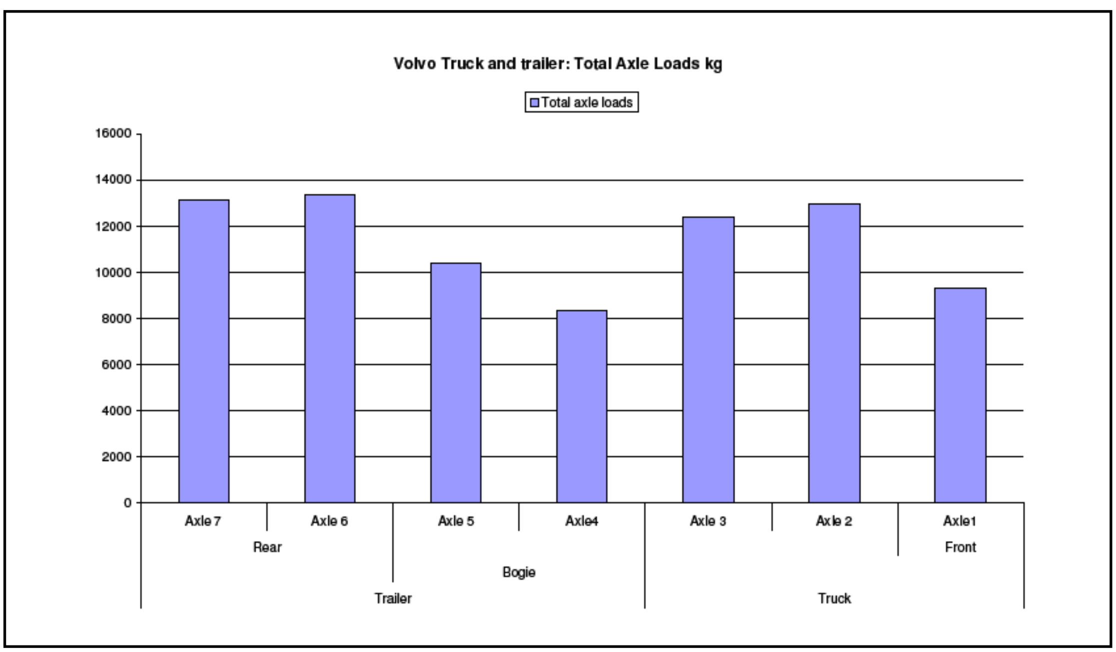
Gross weights

In the above exercise the Gross weight of the Case trailer was measured as being above the plated Maximum Gross Weight of 20.00 tonne. It is accepted that JST have a firm policy of abiding by specified weights and this clearly arose in an effort to fully load the trailer for testing in the yard. However it does emphasise that the physical carrying capacity of timber trailers can exceed the plated weight and this is a matter that timber hauliers have to bear in mind, particularly where vehicles are not fitted with load cell weighing systems.

Illustration 11: Fully laden (overloaded) Case trailer being weighed

Axle loads

The following graphs show the measured axle loads of each unit. The spread of axle weights varies between under 4t (the Case tractor front axle) to over 13t in the case of the Volvo trailer rear axles.



Four axles of the Volvo rig and the two of the Case trailer all exceed the 11.5t Construction and Use limit. This is of interest and may require a review of some forest road design standards.

Vehicles operating on the public road with an axle load of over 11.5 tonne would require to give advance notice and a damage indemnity to the roads authority. If the Case trailer complies with its plated MGW it would lower the axle loading to an acceptable 10 tonne.

It is interesting to note the apparent effectiveness of the balance beam suspension being used on the trailer axles to distribute the loading evenly (Axle 6&7 of the Volvo rig and 3&4 of the Case). This is a reflection of the relatively free rotation of the balance beam arrangement. By comparison there is less rotational freedom in the bogie suspension with a clamped rubber bush providing torsional restraint.

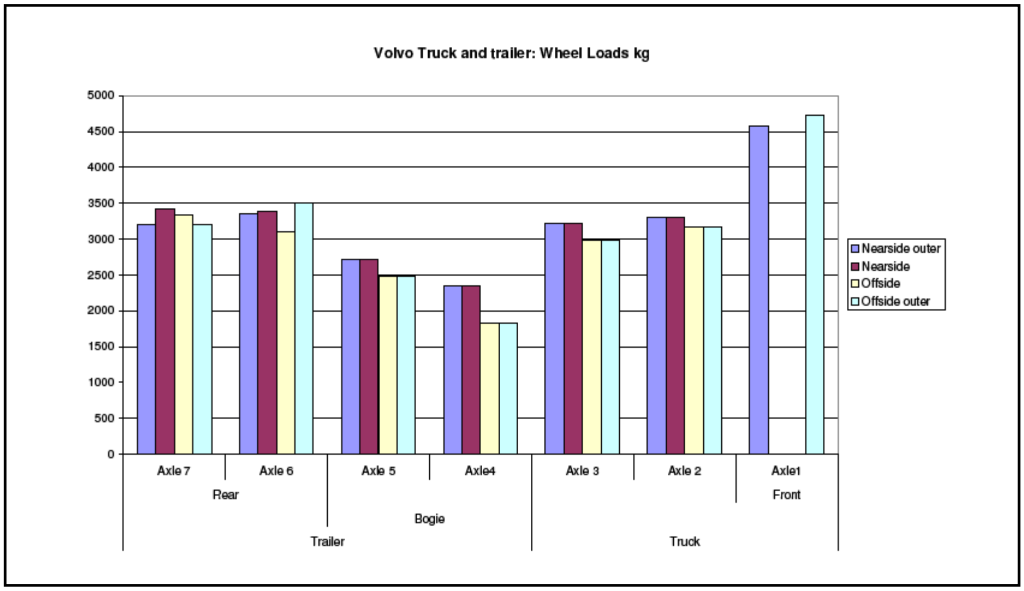
Illustration 12: Photos showing balance beam arrangement on trailer compared to bogie

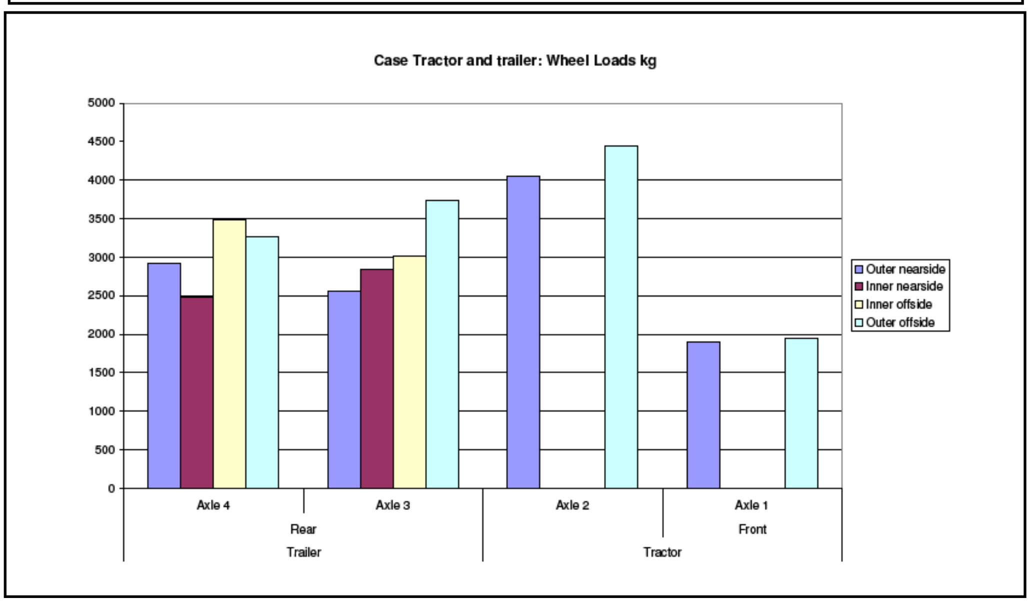
A further point of interest is that axles 4&5 of the Volvo rig have significantly different loads when they might be expected to be equal. The answer probably lies in the fact that the rear bogie axle wheels are offset inwards by 150mm attracting more load to them because of camber effects.

From discussion with JST subsequent to this exercise, it is understood that the aim is now to run the Volvo truck up to 5 tonnes lighter to strike a balance between axle load and the need for good traction on steep hills.

Wheel Loads

The following graphs show the results of the wheel load testing:





The Volvo wheel loads are fairly consistent in the range 1.8-3.4tonne with the exception of the front wheels, each carrying over 4.5tonne. It is important to note that the front tyres of the Volvo are the largest on the rig, and the large contact area will go some way towards mitigating the adverse effect on the road pavement.

Also worth noting is the greater loading on the nearside wheels (Axles 2-5). It is concluded that this is caused by a slight imbalance in loading allied to a tilt of 2% at the measuring site.

In the case of the Case unit the maximum wheel loads are over 4tonne on the tractor rears, which fortunately have the largest footprint to spread this load. The trailer wheel loads are in the range 2.5-3.7 tonne, with a noticeable bias towards the offside.

In considering the implications of these results it must be recognised that both the magnitude and disposition of the wheel and axle loads are different from conventional vehicles. Indeed it is one of the attractions of LGP vehicles that they spread the load in a different fashion. However the potential impact of these loads on existing bridges and culverts may be significant and each route should be properly assessed before use.

For example many forest bridges have timber decks supported on steel beams under the conventional wheeltracks. Loading outwith these wheeltracks may have adverse effects and may require strengthening to be carried out, particularly on older structures. There is clearly a risk of accidental overloading of trailers when working far from conventional weighbridges and robust training and documentation procedures should always be agreed with the contractor.

Swept path

Following a report of increased edge overrun on tight bends a computer generated swept path analysis of the Volvo truck and trailer was carried out. This showed the outer limit of the theoretical swept path was not greatly different from a conventional articulated truck and it is not thought that this is the source of the problem. Further research or monitoring is required as there are a number of things this might be for example:

- Driver approach
- Greater traction demand, eg on steep hills
- Greater lateral forces given the size of the vehicle

The Case tractor and trailer are highly manoeuvrable but experience of large tractor units indicates that they are prone to overrun verges on narrow public roads. The straight line swept path of the tractor is 2.8m wide, many single track roads 3.0m, so there is little room for error. Tractors are unaffected by verge overrun, but the impact on the public in terms of edge rutting and water ponding are highly visible. Things that can be done to alleviate this problem are:

- Driver training
- Cooperation with the roads authority
- Advance minor works or
- Retrospective but timely repairs

On forest roads a greater problem may be traction difficulties on steep and loose surfaces, an area where the Volvo 6x6 with its greater weight and traction is at a distinct advantage.

There is a clear advantage in not mixing road-going and LGP vehicles on a forest road given their different swept paths. Conventional super single trucks encourage development of camber and rutting towards the edge of the road. This is not the ideal surface for LGP trailers which are better suited to straight crossfalls. Mixing the vehicle types using the same road also creates potential for dispute over responsibility for increased vehicle or road maintenance costs.

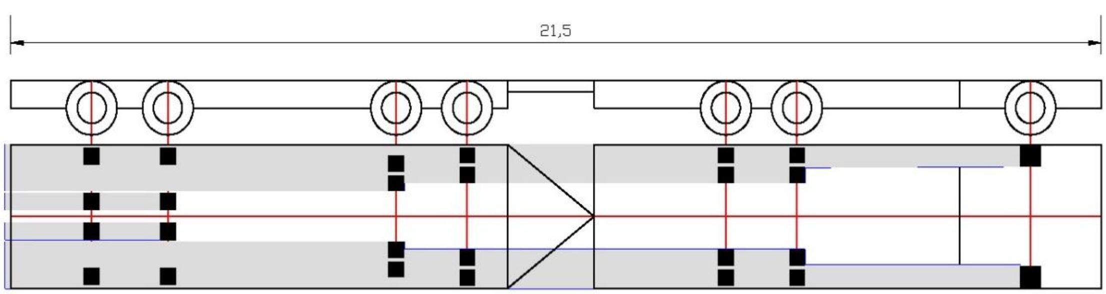


Illustration 13: Diagram showing straight line swept path of Volvo, almost covering roadway

Case Studies

Over the last five years over 500,000 tonnes of timber has been extracted using the JST LGP vehicles. The following are a sample of recent locations with based on experience of the vehicles in action.

Year	Forest	Tonneage out	Vehicle	Approx max round trip haul (km)	Remarks
2006	Backhill of Bush, Galloway	200,000	Terberg	46	Road reported to be in remarkably good condition after large extraction programme
2007	South Kyle	5000 (10,000 to come)	Case	10	Road maintenance included in haulage contract, proving successful so far.
	Carsphairn	30,000	Info awaited	31	£41,300 saving in budgeted capital investment plus £19,000 saving on expected post harvesting works
2007	Loch Ard Forest	32500 (65,000 to come)	Volvo	56	Currently underway. Long haul to avoid public roads and communities
2005	Jura	40,000	Case	5	Short haul on very weak and narrow public road leading to pier. Successful extraction but verge overrun a significant concern to Local Authority
2007	Glen Kin, Dunoon	20,000	Case	10	£6000 increased cost of using LGP more than offset by reduction in budgeted road improvement and maintenance costs of £40,000, yielding a nett saving of £34,000
2007	Stein, Waternish, Skye	30,000	Case	20	Extraction from forest served by weak and narrow public road. Transfer to stockpile on Agreed Route was delayed by need for planning consent. Successfully completed with minimal public road damage, but verge overrun a concern.
	Total	432,500			

Other locations have been:

Year	**Forest**	**Tonneage out**	**Vehicle**	**Approx max round trip haul (km)**	User
2007	Haregrian	20000	Case	15	Kronospan
2007	Greensykes	6000	Case	12	Euroforest
2006	Haregrian	11400	Terberg	15	Euroforest
2006	Greensykes	10000	Terberg	12	Euroforest
2006	Redcleuch	1000	Terberg	20	Kronospan
2006	Carsphairn	36000	Tractor	15	Bidwells
2006	Deuchwater	1200	Terberg	14	Tillhill
2005	Strathwiggan	4500	Terberg	15	Tillhill
2005	Deuchwater	3700	Terberg	14	Tillhill
2004	Deuchwater	8840	Scammell	14	Tillhill
2003	Strathwiggan	2866	Scammell	15	Tillhill
	Total	105,506			

LOGISTICS AND COSTS OF LGP VEHICLES

Cost of Timber Transport Generally

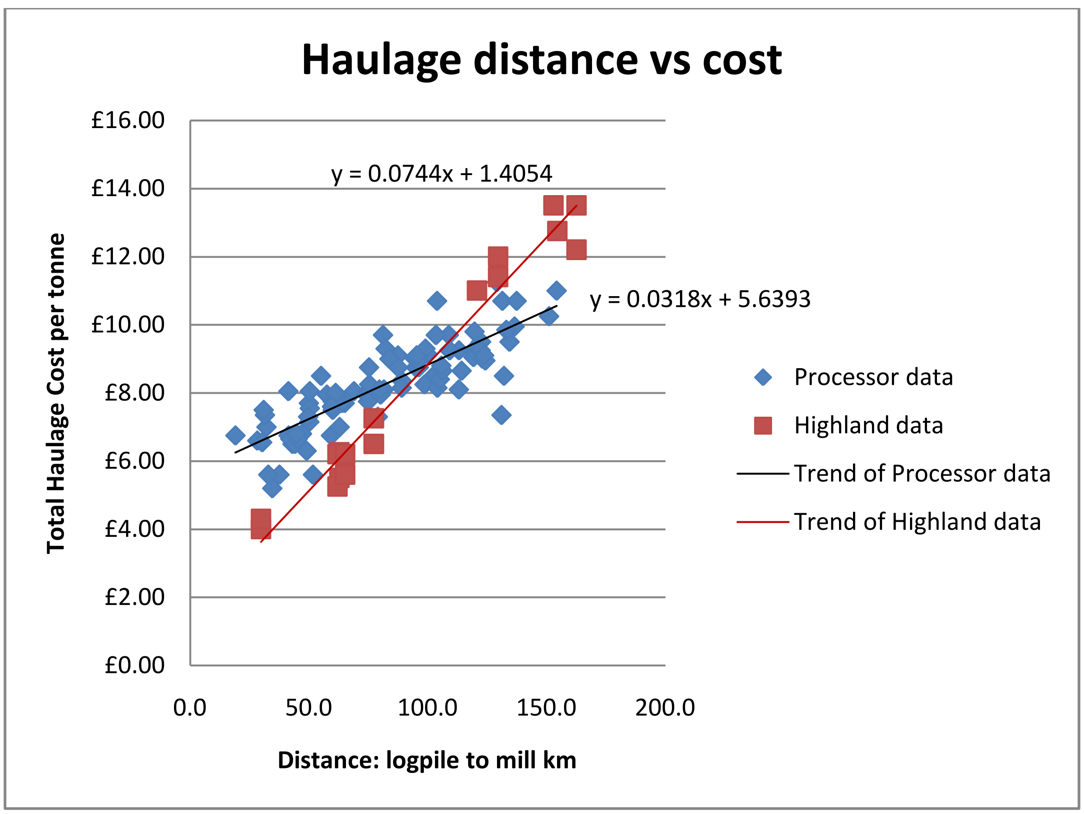
Unfortunately the highly competitive nature of the forest industry is such that it is extremely difficult to acquire robust figures that would enable clear comparisons of different systems to be made. Vehicle running costs in particular are subject to commercial confidentiality and difficult to determine. Different operators have different means of recovering overheads and the costing structure of a single operator is very different from large firms operating 20 vehicles or more.

In order to put the costs of LGP vehicles in context an effort was made to obtain information about general timber haulage rates and, for the reasons stated above, this proved to be a significant impediment to the completion of this report. No one on the production chain wishes to divulge costs for fear of losing the slightest commercial advantage, and any mention of costs is always couched in generalities.

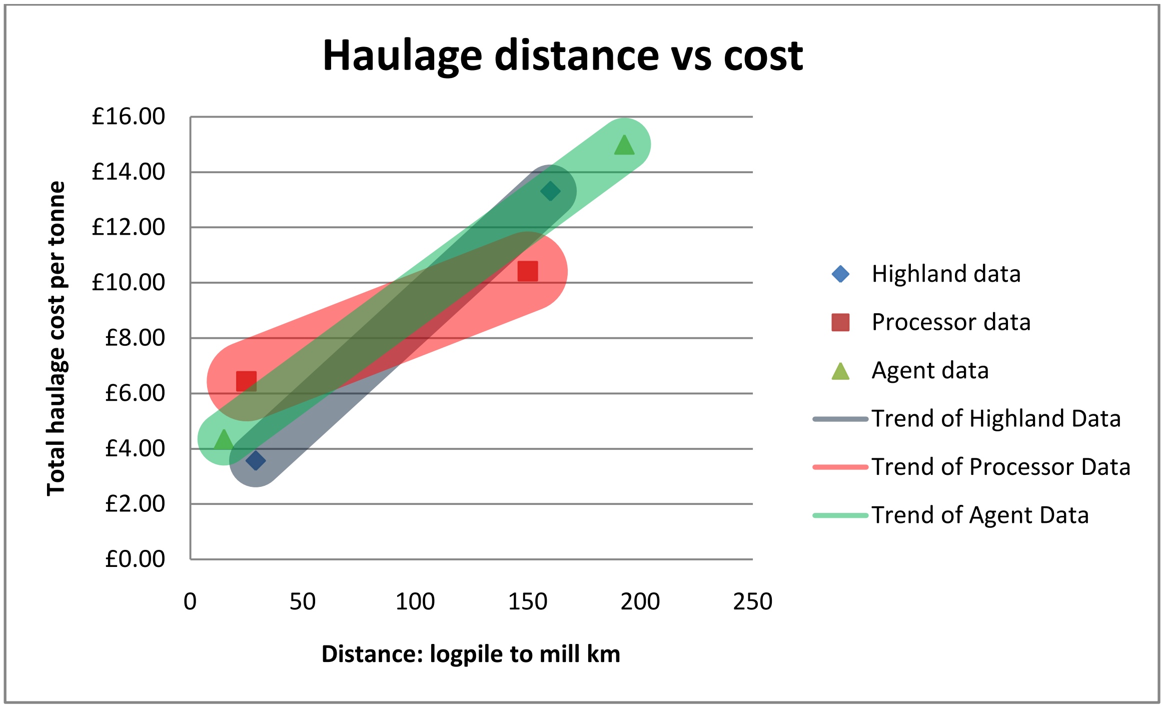
Fortunately a significant amount of information has now been accessed from three different sectors in the chain, giving some confidence as to its accuracy. The sources are as follows:

Source	Information obtained
Forest Enterprise, Highlands	17 data points covering 10 forests with journey lengths between 29 and 160km. Limited LGP data on one forest.
Processor (name retained in confidence)	Data covering haulage rates, including information on distances in forest 97 points with journeys between 30 and 155km using road-going transport.
Agent (name retained in confidence)	Sight of a graph of general haulage rates, no information on distance in forest or LGP transport. Journeys between 15 and 200km

The Processor and Highland haulage data has been analysed to produce the following graph, showing the data with best fit linear trend lines:



When analysing the data it became clear that there was a high degree of scatter in the results and that there was no apparent means of eliminating this. In the following graph the Agent data has been added and the trend lines have been plotted to give an approximation of this scatter. This varies from +/- £1.50/tonne in the case of the Highland and Agent data to more like +/- £1.75/tonne in respect of the more comprehensive Processor data.



A number of key conclusions are drawn from the data and graphs:

1. There is a reasonable fit between the Highland and Agent data but the slope of the Processor data is significantly flatter with a higher intercept on the cost axis. This suggests that the Processor has to pay more "up front" for short distances, with a lower marginal rate for each extra kilometre. This would appear to be a feature of market conditions.

2. The average rate per tonne-km for hauling timber is 11.6p based on the Processor data compared to 9.5p for the more limited Highland data. This is a significant difference (22%) and must be presumed to reflect differing market or site conditions.

3. The data scatter is caused by the many variables that impact on the price quoted for a job. It is clearly not realistic to believe that the relationship between cost and distance can be defined as a clean straight, or even curved, line. The extent of scatter is substantial, at between £3.00 and £5.00. For example the graph indicates that a 100km

haul could be expected to cost somewhere between £7.25 and £10.50, but that is hardly accurate enough to make a commercial judgement in tight trading conditions. Regular market testing and competitive tendering are clearly essential to ensure best value for money.

4. Any attempt to compare the cost of innovative LGP vehicles with conventional vehicles is fraught with statistical uncertainty unless they are compared "head to head" by competitive tendering at the same location. That is because the cost differences between apparently similar locations can be so great as to mask or exceed the cost differences between the modes.

5. There is anecdotal evidence of there being a substantial premium to be paid for road-going artics travelling deep into the forest but it has not been possible to quantify this with any certainty from the data available. Neither the Processor data (up to 12km in forest) nor the Highland data (up to 7km in forest) showed the step-change in costs that might have been expected.

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Additional work carried out to derive comparative costs is included as Appendix A.

LGP Vehicle Costs

The following table gives an indication of the key factors affecting the costs of using LGP vehicles compared to using a conventional articulated lorry for the whole journey:

Component	Comment
LGP vehicles travelling in-forest	High vehicle costs but greater payload (Volvo) and flexibility of use (Case) helps offset this
Fuel cost	Significant savings where rebated fuel can be used
Transhipment	This is a significant additional cost that must be recouped by savings made elsewhere
Artic travelling on public roads to the mill	Savings can be made with trucks running exclusively on public roads, use of skeletal trailers and trailers without crane
Forest roading and road maintenance	Possible savings in road construction and maintenance costs.

For the purpose of this report costs have had to be assumed and this is explained further in Appendix A.

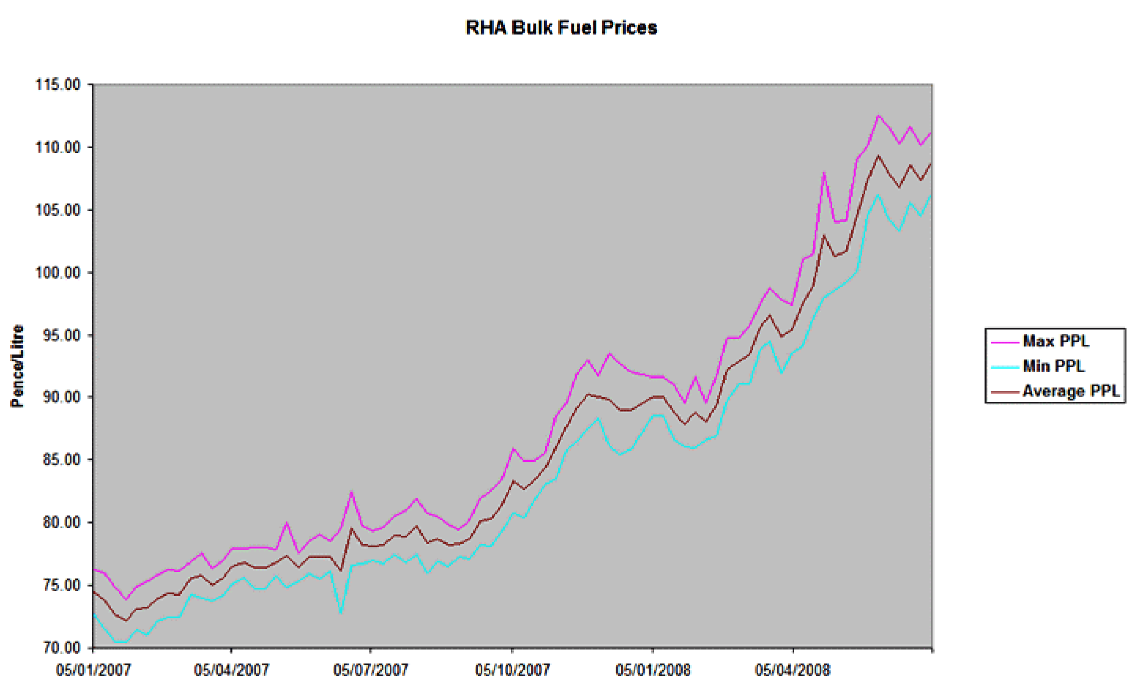
Fuel

Conventional haulage vehicles must pay Road duty rates on their fuel but the use of Rebated Fuel (red diesel) can be permitted for "excepted vehicles". This is a complex area of law and to assist interpretation HM Revenue and Customs have recently issued a helpful Memorandum of Agreement (Reference 3) after consultation with the Confederation of Forest Industries and other groups.

The saving from using rebated fuel is highly significant as the following table shows:

Costs per litre (May 2008)	**Diesel**	**Rebated Diesel**	**Saving**
Base cost	£0.55	£0.55	
Duty	£0.5035	£0.0969	£0.4066
Duty paid price	£1.05	£0.65	£0.41 (39%)
Pump price including VAT	£1.23		

With fuel now comprising over 35% of the running cost of a truck the use of rebated fuel cuts the overall haulage cost by about 14%. The rapid rise in fuel costs in 2007-08 can be seen in the following graph prepared by the Road Haulage Association (RHA):



It might be expected that the increase in the base cost of fuel would increase the attractiveness of Rebated Fuel. However because the differential in duties between Road and Rebated fuel has recently been static, the percentage saving from using rebated fuel has actually being eroded. For example between May 2007 and May 2008 the UK duty differential remained constant at 40.66p, the increase in fuel duty in October 2007 of 2p being applied to both types of fuel equally. A saving of 40.66p in May 2007 represented a 52% saving in using rebated fuel when the base fuel was only costing 29p per litre. However, as can be seen from the above table, this saving had declined to 39% by May 2008, when the base cost had risen to 55p per litre. The saving per kilometre has remained static, depending on the fuel consumption:

Typical running	Assumed litres/100km	Assumed mpg	Saving pence per km (mile) travelled	
Good tarmac road (as quoted in FE/SE report	28.8	9.8	12 (19)	Based on current duty differential of £0.4066p per litre
Public road (as quoted by RHA)	39.2	7.2	16 (26)	
Timber haulage (as quoted by FE/SE report)	47.1	6.0	19 (31)	

Licensing

When vehicles are used exclusively in-forest to extract timber they can also be subject to relaxations from the need to comply onerous licensing, taxation and other requirements such as the Construction and Use regulations and Vehicle Testing regulations.

It is beyond the scope of this report to go into these in detail other than to note that this can result in significant savings. However it must also be recognised that the use of agricultural vehicles in lieu of highly regulated road haulage vehicles is an area open to abuse. It is important that public authorities, and private sector clients, strive to keep a level playing field to ensure that those contractors who fully comply with the law are not disadvantaged.

Transhipping

The JST vehicles will almost always be used in a situation where transhipment will be needed to get the product to market. Transhipment costs are significant and must be included in the equation.

It takes about 30 minutes to load or unload a vehicle (including strapping) and this is effectively downtime for the vehicles involved. These costs will be different between the Volvo which can self load/unload and the Case units which require lifting facilities to be available at either end.

Illustration 14: Offloading plant awaiting Case at South Kyle at convenient existing hardstanding

Providing and maintaining an adequate landing, storage and turning area also has costs depending very much on the size and location. Where this is not in the forest, for example if LGP tractors are hauling to the nearest point on an Agreed Route, land acquisition, planning and other potential difficulties need to be borne in mind. It is important that tendering procedures fully expose these costs if comparisons between different contractors/methods are to be fairly compared.

The following table gives an indication of the magnitude of the considerable additional costs involved in transhipment involving double handling of the timber.

Operation	**Calculation**	**Cost per tonne**
Unloading from 80t LGP truck	40 minutes at say £65 per hour for 45tonne	£1.00
Loading road-going 44t truck	30 minutes at say £50 per hour for 25tonne	£1.00
Construction and maintenance of hardstanding	Depends very much on location and work involved; say £5000 for 50kt to be extracted	£0.10
Typical minimum transhipment cost		**£2.10**

Illustration 15: Large transhipment areas have costs to build and maintain

Onward road transport to mill

Stockpiling and transhipping does have the advantage of smoothing the peaks and troughs of in-forest activity ensuring continuity of supply to the road-going trucks heading for market. In addition this provides the opportunity to use dedicated road-going vehicles for the remaining journey to the mill and this can have significant cost advantages. Three options are considered:

Using conventional artics:

It has been mentioned above that an artic dedicated to road use incurs significantly lower running costs compared to a vehicle having to drive in-forest.. The figures in the FE/SE report suggested a possible saving of 45%, although at current prices this would seem to be overstated.

Using conventional artics without crane:

A further saving of up to 15% can be achieved if the road-going artic does not have the dead weight of a crane, resulting in a payload of 29t versus the usual 25t. However this saving can only be realistically achieved where loading equipment is available at the transhipment point.

Using skeletal trailers:

The use of skeletal trailers parked at the landing area is another option. Without a crane these also have the advantage of the 15% greater payload. Where they can be directly loaded from the incoming LGP vehicle they will also reduce the transhipment cost by roughly 50p per tonne in addition to the transport cost savings.

Illustration 16: Skeletal trailer parked at a transhipment point

The use of skeletal trailers is not as widespread as these savings might suggest and a number of reasons can be put forward to explain this including:

- the more complicated logistics
- the reluctance of drivers to take responsibility for trailers loaded by others and the management and safety implications of this
- the need to have a sufficient number of trailers, sometimes sitting idle for long periods, and to be able to absorb the cost of these
- the fact that the system works best with a single product and destination, for example pulp wood in bulk rather than variable sawlogs requiring selection.

Road Maintenance

A useful report worth mentioning here is the Review of Timber Haulage and Forest Roads – Solutions for Cost-effective Transport and Strategic Benefits for Scotland (Forest Enterprise/Scottish Enterprise 2003) (Reference 1). The cost of forest road maintenance based on experience in Galloway was quoted in this report as £1.00 (£1.15 allowing for inflation) per tonne. More recently a figure of £0.10 per tonne per km (one way) has been suggested in the wider industry as being more appropriate. This equates reasonably to the Galloway figure for a run 11.5km deep into the forest.

These figures must be treated with caution as they include elements of minor capital expenditure as well as reactive maintenance, but they do indicate the scale of the cost. This is a substantial sum, similar in magnitude to the cost of the timber haulage itself within the forest.

Putting it simply for emphasis:

"*For every pound spent hauling timber out of the forest another pound can be spent maintaining the road*".

A key perceived advantage of the LGP trailers is the reduction in damage to the forest road network and solid anecdotal evidence of this has been found in both the public and private sectors.

The best of this evidence is from the Case Study sites where comparable overall prices could be obtained, including not just the transport but also any road construction and maintenance costs. These point to significant savings having been made from using LGP vehicles.

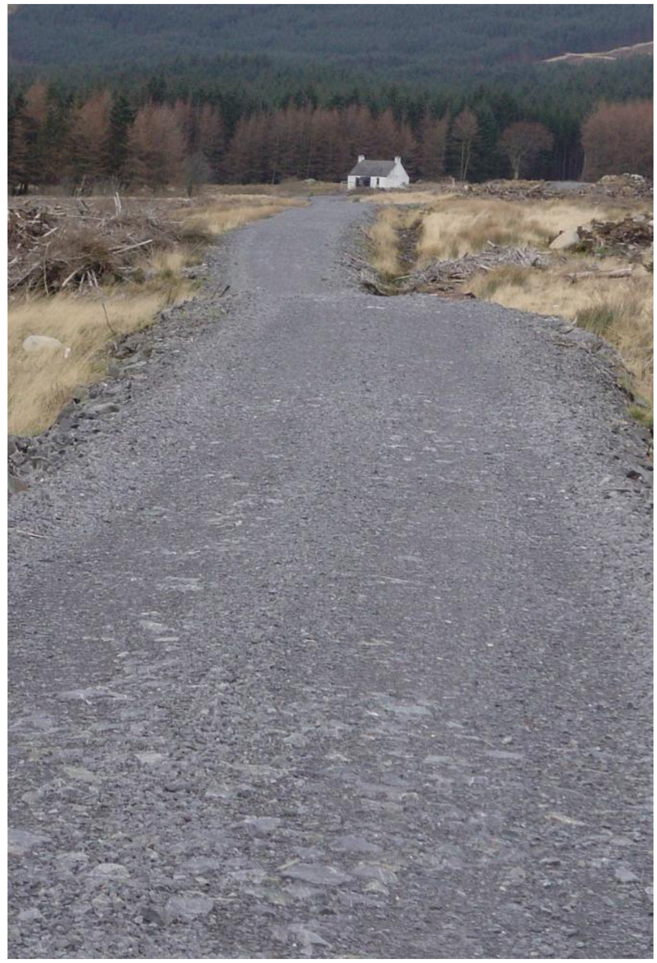


Illustration 17: Heavily trafficked road at Backhill of Bush, Galloway showing little damage under LGP vehicles

Unfortunately at this stage it is impossible to draw generalized conclusions about the extent of savings available and each case must be considered on its merits. The raw data needed to prove the case has not traditionally been collected by the industry and there are simply too many variables and unknowns. For example:

- What is the true cost of the normal road maintenance regime?
- What is the true cost of the maintenance regime now required?
- Is the section of road sufficiently uniform to draw conclusions?
- Have the actual vehicle weight and wheel/axle loads been regularly monitored?
- If the road is failing is it due to factors unrelated to the vehicle configuration?
- Has the weather been monitored and in any way been exceptional?
- What proportion of the damage can be attributed to vehicles sharing the road eg super singles etc?

Current tendering procedures are unlikely to expose the true value of LGP transport, with a concentration on the lowest haulage rate per tonne. Repairing contracts, where the haulage contractor undertakes road maintenance as well as extraction would better identify the true overall comparative cost.

An alternative might be partnership contracts with the haulage contractor and the forest owner agreeing on essential maintenance and its cost. Such contracts might be difficult to impose on shared access routes with multiple owners/agents but there can be little doubt that giving the haulier a stake in the standard of road maintenance has clear overall advantages.

When is LGP Transport Cost Effective?

The above analysis has identified a key factor in assessing the cost effectiveness of using LGP vehicles: the cost of transhipment. Transport using conventional artics on a single journey does not incur this cost penalty and it is a significant hurdle to overcome.

The Desk Study in Appendix A assumes comparative figures of 19p and 15.1p per tonne-km for a conventional artic operating in-forest and LGP vehicle respectively, giving a saving of 3.9p per tonne-km in favour of the LGP vehicle when running head to head. This makes intuitive sense in that a high capacity dedicated truck, running on rebated fuel and outside Drivers Hours regulations must surely be cheaper than a road-going truck driving deep into the forest. The reality of costs may be somewhat different but this will be discussed later.

Using this figure of 3.9p per tonne km it is clear that any saving in the use of the LGP vehicle will only be able to offset the £2.10 cost of transhipment when the trip exceeds 50km deep into the forest.

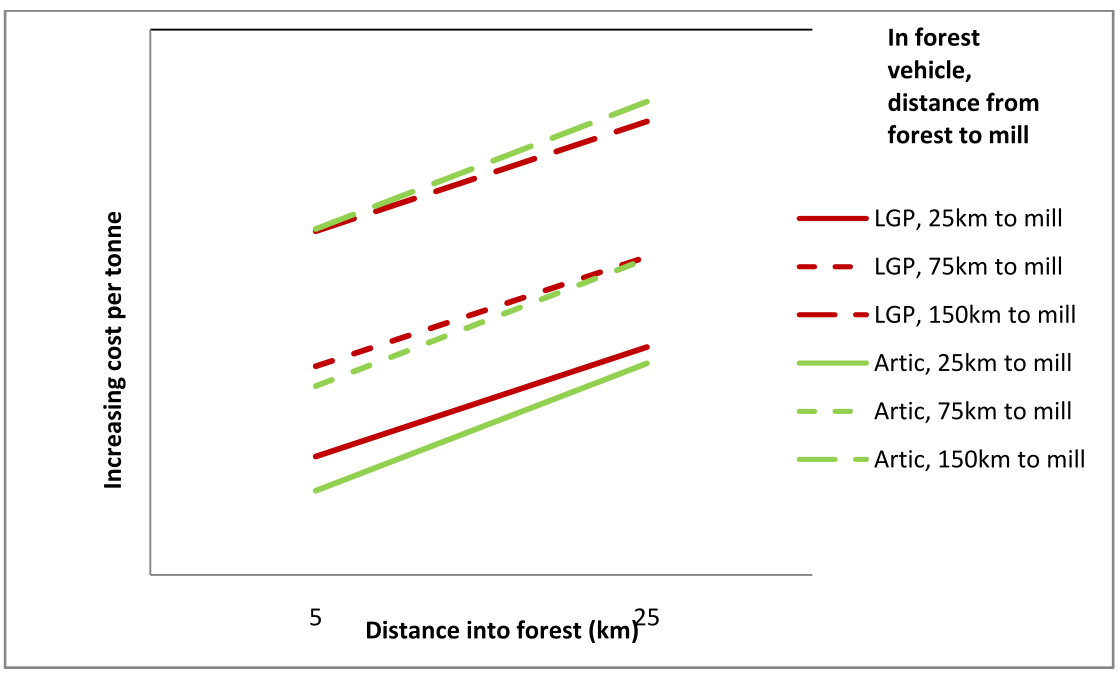
This breakeven point should not be viewed as absolute but it does demonstrate the principle. It is clear that for LGP transport to be cost effective for shorter journeys the whole cost of the operation must be taken into account, not just the in-forest haulage, but including:

- transhipment
- onward transport to the mill, preferably using skeletal trailers or trailers without crane
- any identified saving in road construction and maintenance costs.

An example of this type of calculation, using figures from Appendix A is shown in the table below.

		Using LGP vehicle, transshipping on to skeletal trailer		*Using conventional vehicle for whole journey*	
Component	**Distance**	**Cost**	**Total**	**Cost**	**Total**
In-forest haul	20km one way	£0.151x20 using rebated fuel	£3.02	£0.19x20	£3.80
Transhipment		£2.10	£2.10		
Road transport to mill	100km one way	£0.082x100	£8.20	£0.095x100	£9.50
Forest road maintenance cost	20km length	£0.10x20	£2.00	£0.10x20	£2.00
Total			£15.32		£15.30

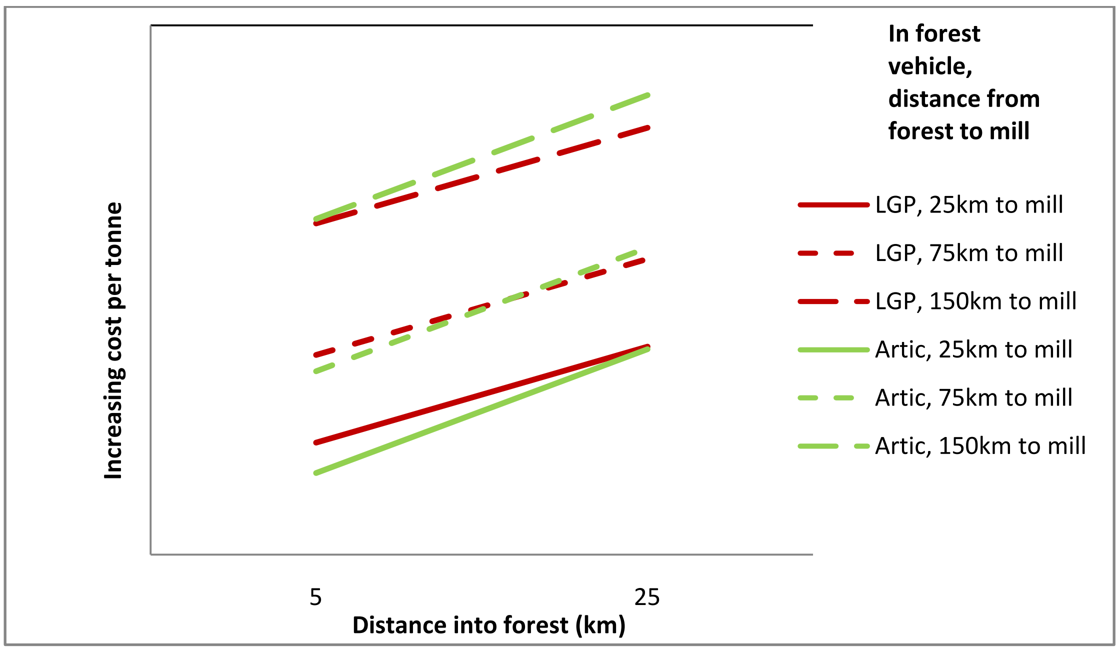
These figures have been entered into a spreadsheet to produce the following chart which gives a useful indication of the way the costs and distances interact:



It can be seen that for short hauls to the mill, LGP transport will only become cost effective for very deep forest hauls. As the distance to the mill increases LGP transport becomes more attractive, with the lower cost of using dedicated road-going vehicles on the leg to the mill offsetting the transhipment cost.

Eventually, with long hauls to the mill, using LGP vehicles can become attractive even for fairly short forest legs.

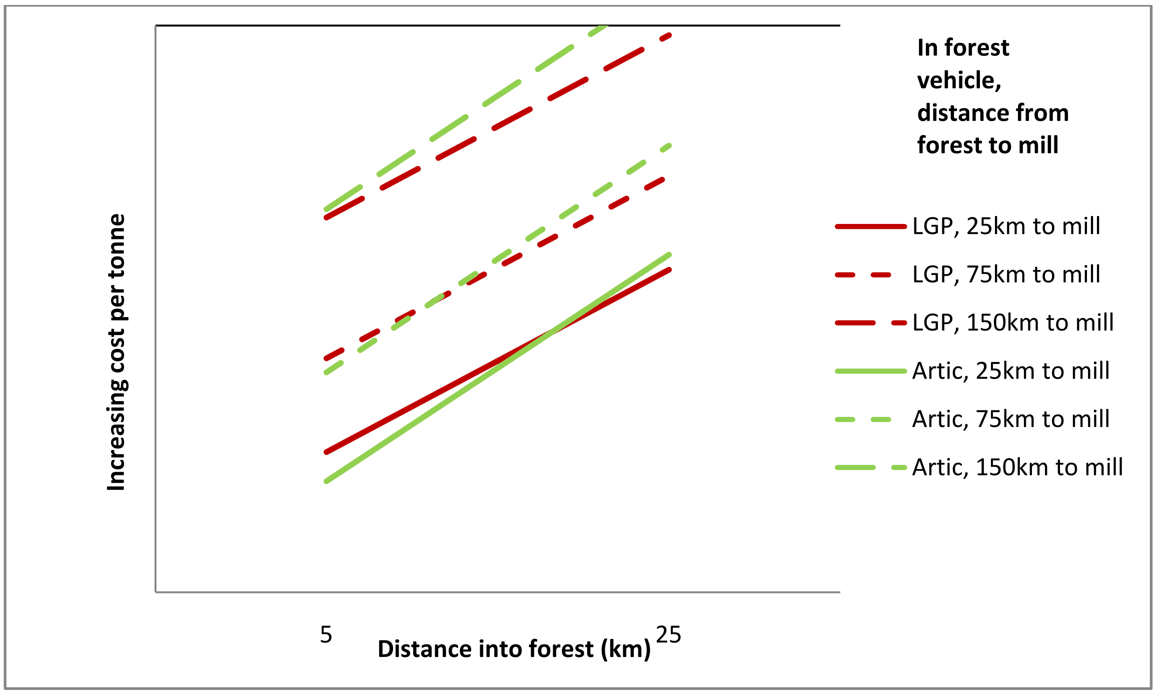
If a 25% saving in road maintenance costs can be identified the shape of the previous graph changes as follows:



In reality the position is more complicated. The study has ascertained that comparative road maintenance costs are difficult to obtain and the true costs of running a road-going artic deep into a forest are not able to be established from the data available. The figures in Appendix A therefore assume the cost of a road-going artic running in-forest to be double that of running on the public road (£2.40 per km vs £1.20 per km), although a lesser multiplier of 1.5 times is often quoted anecdotally.

The only tendered figures for LGP transport available to the study suggest that the cost of operating the LGP truck deep in forest may be several times the cost of operating an artic on the public road, perhaps double the £3.40 per km assumed in Appendix A. This may seem high but must be compared against anecdotal evidence of hauliers looking for an extra £5 per tonne for artics to travel much beyond 10km into the forest. Assuming a 30km round trip in-forest and a payload of 25t, such a premium equates to an extra £4 per km, suggesting that £5-6 per km may not be unreasonable to cover the risks involved in taking a road-going artic deep into the forest.

If these higher figures are used (£5/km for the artic, in-forest, £6.80/km for the LGP vehicle) the following graph ensues, without allowing for any road maintenance savings:



This graph shows the LGP vehicle gaining advantage over the artic for deeper and longer journeys, based on these input rates. Unfortunately the lack of hard data on the true costs of running an artic in-forest head to head with a LGP vehicle means that this result must be treated with caution until more robust evidence is to hand.

These charts must not be taken as definitive given the wide variability of the costs that can be fed in to the calculation. However they do provide a stimulus for recognising and considering how the factors interact.

To summarise, the situations where LGP transport will be most cost effective are:

- Where operations are deep in-forest (Volvo) or in difficult access situations (Case)
- Where any savings in road construction costs or damage due to LGP use can be properly assessed and included in the equation
- Where transhipment costs can be minimized
- Where dedicated road transport can be used to make savings on the remaining journey to the mill, using parked skeletal trailers or trucks without cranes where practicable
- Where the journey from forest to mill is long enough to generate these savings

Neither the Highland nor the Processor figures quoted in Appendix A show any obvious uplift in rates for a road-going artic travelling up to 12km into the forest. It is therefore suggested that 10km be used as the break point for considering LGP transport, unless there are unusual roading issues.

Illustration 18: Case trailer in weak road conditions

Where Should LGP Vehicles Be Considered?

The JST LGP vehicles provide another tool to aid timber extraction and they complement rather than compete with road-going vehicles. Together with vehicles using Tyre Pressure Control Systems (sometimes called Central Tyre Inflation, see Reference 2)) they provide a range of options for use in difficult access situations.

The following table is not intended to be definitive but does indicate where LGP vehicles should be considered. Decisions will depend on local costs and site conditions.

Situation	**Conventional super single artic (25/29t payload)**	**Specialist (eg: twin wheel and/or TPCS (CTI) equipped)**	**Tractor +LGP trailer (15t payload)**	**Specialist LGP (45t payload)**
Served by agreed route, short journey in-forest (<10km one way)	Strong forest road	Strong/weak forest road		
Served by weak consultation route, short journey in-forest (<10km one way)			*Hauling to roadside stockpile for transfer*	
Short/medium in-forest haul to stockpile in-forest				
Long in-forest haul to stockpile in-forest(10km+ one way)				

Conclusions

This report provides a summary of recent experience gained from the use of the JST Low Ground Pressure Volvo and Case units with a view to their wider application. Although, for reasons explained in the report, hard comparative costs are difficult to obtain an effort has been made to identify the types of situation where they can be used to greatest benefit.

The following are the key findings:

1. The use of LGP vehicles for timber transport has potential to significantly cut the combined cost of timber transport and road maintenance. They will not provide a universal solution and each situation must be considered on its merits.

2. The Volvo units are best suited to long haul situations whilst the Case units provide a useful tool for sourcing timber from difficult locations. In some places they may prove acceptable to Local Authorities for use on short lengths of weak Consultation or even Excluded Routes, enabling release of otherwise landlocked timber. A distance of 10km in-forest has been suggested as the review point for using LGP transport, although the Case units may be cost effective at lesser distances where there are roading issues.

3. The cost of transhipment from the LGP vehicles to conventional road transport is highly significant and it is important that any costing comparison takes into account the whole cost of roading, in-forest haulage, transhipment and onward road transport to the mill.

4. Forest road maintenance costs are also highly significant with some justification given for the statement: "*For every pound spent hauling timber out of the forest another pound can be spent maintaining the road*". It is recommended that procurement and costing procedures are reviewed to ensure that the true cost of haulage plus road maintenance can be more readily identified. This would support better decision making and ensure a level playing field on which innovative vehicles can be fairly and transparently assessed.

5. The use of skeletal trailers with reduced deadweight and greater carrying capacity offers significant savings on the public road leg of the journey to the mill. The use of such trailers is limited at present and a number of reasons have been put forward to explain this. With fuel costs and carbon footprint increasingly important this subject is worth further investigation.

6. The distribution of loading under LGP vehicles is different from traditional timber trucks; indeed that is one of their key advantages. However care must be taken to ensure that forest road structures are reviewed to ensure that they are capable of taking these loads. For example, fragile timber bridges might be properly supported under the conventional wheel tracks but found to be unsafe when loaded by wheels in the centre of the road. Routes proposed for LGP traffic should therefore be fully assessed before use.

7. LGP vehicles will normally work in the forest and will not be routinely weighed. If the full benefits of reduced road damage are to be realised it is important that suitable training and documented procedures are in place to ensure that overloading does not take place.

8. There is a clear advantage in not mixing LGP vehicles and road-going trucks on a forest road at the same time, given their different swept paths. Conventional super single trucks encourage development of camber and rutting towards the edge of the road, whilst LGP trailers which are better suited to straight crossfalls.

9. Comparative costs in the highly competitive forest industry are difficult to obtain and analyse, but an assessment based on available costs was carried out and is fully described in Appendix A. This suggests that at least some current timber haulage rates are not dissimilar to conventional road haulage rates inferring that they may not be sustainable at their present level.

10. From the cost data obtained it is clear that haulage rates are subject to a high level of variation and scatter. This can be justified given the many variables involved in timber transport but it is important that customers carry out regular market testing and competitive tendering are used to ensure best value for money.

11. The industry has had to adapt to rising fuel costs and has to make continuing efforts to reduce carbon emissions. Deep forest working is likely to increase and it is important that innovation is encouraged and information shared if the full benefits are to be derived. This report has commented on the lack of hard information and costs available on deep forest haulage and it is recommended that the position is reviewed when further experience is gained and more information becomes available.

Selected references

1. Review of Timber Haulage and Forest Roads – Solutions for Cost-effective Transport and Strategic Benefits for Scotland; Forest Enterprise/Scottish Enterprise; March 2003; http://www.timbertransportforum.org.uk

2. Tyre Pressure Control on Timber Haulage Vehicles: Some Observations on a Trial in Highland, Scotland; Ron Munro, Frank MacCulloch; February 2008; http://www.roadex.org

3. Memorandum of Agreement in respect of the use of agricultural vehicles; HM Revenue and Customs; January 2008; www.hmrc.gov.uk

APPENDIX A: DERIVATION OF COMPARATIVE COSTS

Introduction

The consensus amongst hauliers is that standard pricelists are impractical, with each job having to be priced on its merits taking into account factors such as:

- Dead mileage (eg base to forest)
- Distance in-forest and condition of road
- Distance forest to mill and characteristics of the public road
- Downtime, delays, traffic congestion etc
- Multiple jobbing, enabling short hauls to be mixed with long to fill the day and gain better utilisation
- Total tonneage and scale of the job
- Vehicle characteristics, payload and running costs
- Compliance with legislation, drivers hours etc.

Because of this it has to be concluded that there are no hard and fast hourly or mileage rates that can be used to carry out a comparison between conventional and LGP vehicles. There are simply too many variables. However there is believed to be merit in considering the figures that are available and a desk study has been carried out using these. The limitations of this approach must be recognized but the results provide a useful supplement to anecdote.

Vehicle Costs

Previous work on the subject of vehicle costs has been carried out and is described in the report Review of Timber Haulage and Forest Roads – Solutions for Cost-effective Transport and Strategic Benefits for Scotland (Forest Enterprise/Scottish Enterprise 2003) (Reference1).

That report includes a comprehensive assessment of the costs of running timber haulage vehicles compared with conventional road haulage. The costs from the report require to be updated December 2001 base, to allow for inflation and fuel price rises.

The Road Haulage Association (RHA) publishes a comparison of inflation indices and these are shown in the following table in respect of the uplift from 2001 to 2007:

Year	RHA Cost index	RHA Rate index	RPI
2001	178.8	128.1	149.7
2007	235	142.6	178.6
Uplift	32%	11%	19%

These figures reflect the pressures affecting the haulage industry in recent years with costs outstripping market rates by a considerable margin. The 32% cost uplift figure has been selected to update the figures in the above FE/SE report:

Dec-01 Costs	**Typical Road Haulage**	**Timber Haulage**
Total annual cost	£73,376	£131,133
Cost per mile	£1.05	£1.87
Dec-07 Costs		
Inflation	1.32	1.32
Total annual cost	£96,856	£173,095
Cost per mile	£1.39	£2.46
Cost per km	£0.86	£1.53
Hourly charge	£40	£72
Daily charge	£400	£720

As further validation of this approach current 2008 figures have been obtained from the RHA website. These indicate that industry average costs for a 44tonne 6x2 road-going artic with a tri-axle trailer are:

	Tractor	Trailer	Total
Time related costs per annum	£69,320	£2,639	£71,959
Mileage related costs per mile	76.2p	5.5p	81.7p

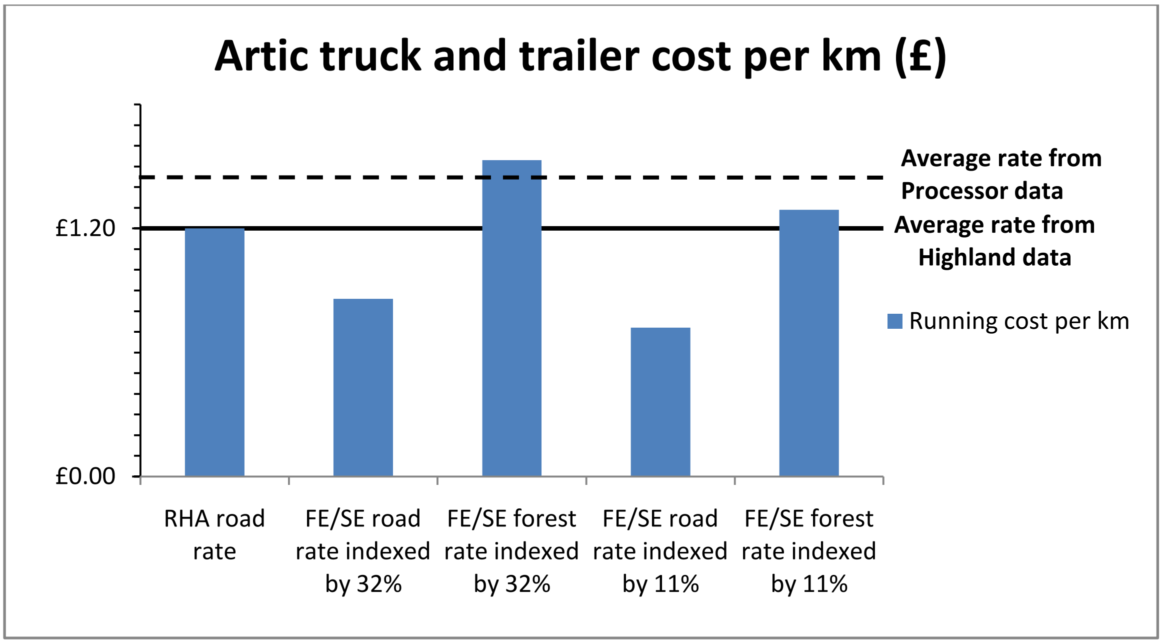
On the basis that this unit travels 70,000 miles per annum, the total charged out over the year will be:

RHA road-going vehicle costs	
Time related costs	£71,959
Mileage, 70,000@81.7p	£57,190
Total	£129,149
Add profit, say 5%	£6457
Total to be charged out	£135,606
Cost per km needed to recover above@113k km/annum	£1.20 (£1.92 per mile)

This total is some 40% above the typical road haulage cost (£0.86 per km) derived from the FE/SE report including inflation. Whilst some of the difference can be explained by a rapid increase in fuel costs in early 2008 the disparity appears to arise from significantly higher insurance, labour and overheads costs used in the RHA calculation. The following table shows the original 2001 figures from the FE/SE report, with the current RHA figures alongside for comparison:

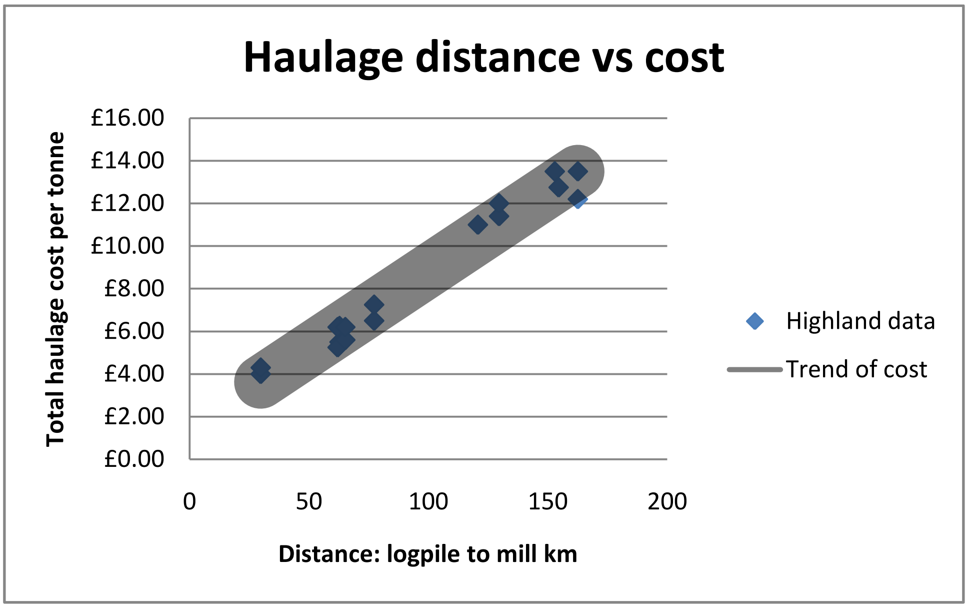
Typical Road Haulage costs							
Figures based on 44 Tonne (gross) articulated vehicle with triaxle trailer							
Data source	FE/SE report Dec 2001			RHA Average figures 2008			
Annual Mileage	70,0000 miles			70,0000 miles			
Life of Tractor in years	7 years			6 years			
Life of Tractor in miles	490,000 miles			420,000 miles			
Life of Trailer	12 years			10 years			
Cost of Tractor	£48,940			£66,000			
Cost of Trailer	£20,948			£18,200			
Fuel Consumption	9.8 MPG			7.2 MPG			
Fuel Price per liter	£0.62			£1.05			
Tire Life in miles Tractor	58,000 miles			65,000 miles			
Tire Life in miles Trailer	49,000 miles			55,000 miles			
	Cost £ p.a.	Cost pence/ mile	% Cost	Cost £ p.a.	Cost pence/ mile	% Cost	**Increase** *2001-08* %
Vehicle Road Tax	£1200	1.72	2%	£1200	1.72	1%	0
Insurance	£2,297	3.27	3%	£4150	5.93	3%	80
Depreciation of Tractor	£6,169	8.81	8%	£11,000	15.71	9%	78
Depreciation of Trailer	£1,746	2.49	2%	£1,820	2.60	1%	4
Total Standing Costs	£11,412	16.29	15%	£18,170	25.96	14%	
Fuel	£20,106	28.72	27%	£46,410	66.30	35%	130
Tires (tractor and trailer)	£2,591	3.70	4%	£2,520	3.60	1%	0
Maintenance (both t & t)	£7,345	10.49	10%	£8,260	11.80	6%	12
Total Running Costs	£30,042	42.91	41%	£57,190	81.70	44%	90
Employment Costs	£19,674	28.11	27%	£29,000	41.43	23%	47
Overheads	£12,248	17.49	17%	£24,789	35.41	19%	102
Total Costs Overall	£73,376	104.8	100%	£129,149	184.5	100%	76

The following chart shows the above RHA road-going vehicle cost compared to the earlier FE/SE report costs. The latter are lifted from their 2001 base using the 32% (Cost) and 11% (Rate) indices mentioned above. Also plotted are the average Highland and Processor rates, discussed in the next section.



Timber haulage rates

It has been possible to obtain representative current haulage figures from Forest Enterprise in the Highlands covering 10 forest locations with logpile to mill journeys varying from 29km to 160km (18-100 miles). The cost per tonne is shown on the following graph:



It can be seen that the cost per tonne increases in a roughly linear fashion with a data scatter width of +/- £1.50. The trend line crosses the price axis beween zero and £3.00. This makes sense as it broadly reflects the fixed costs of loading and unloading which are not distance related. If this fixed element of cost is stripped out the marginal rate per tonne km varies between 7p and 10p with an average of 8p.

To enable proper comparison the fixed element will be included and the total average price of 9.5p per tonne km will be used to compare costs. For a 25t payload on a 44t artic this equates to a total charge of £2.38 per km (£3.80 per mile). It is important to note that this charge is only levied on the loaded journey to the mill and the effective rate being charged is half these rates ie £1.20 per km (£1.92 per mile) actually travelled. Coincidentally, these figures are the same as the RHA figures for road-going transport, despite the fact that timber transport would be expected to be more costly.

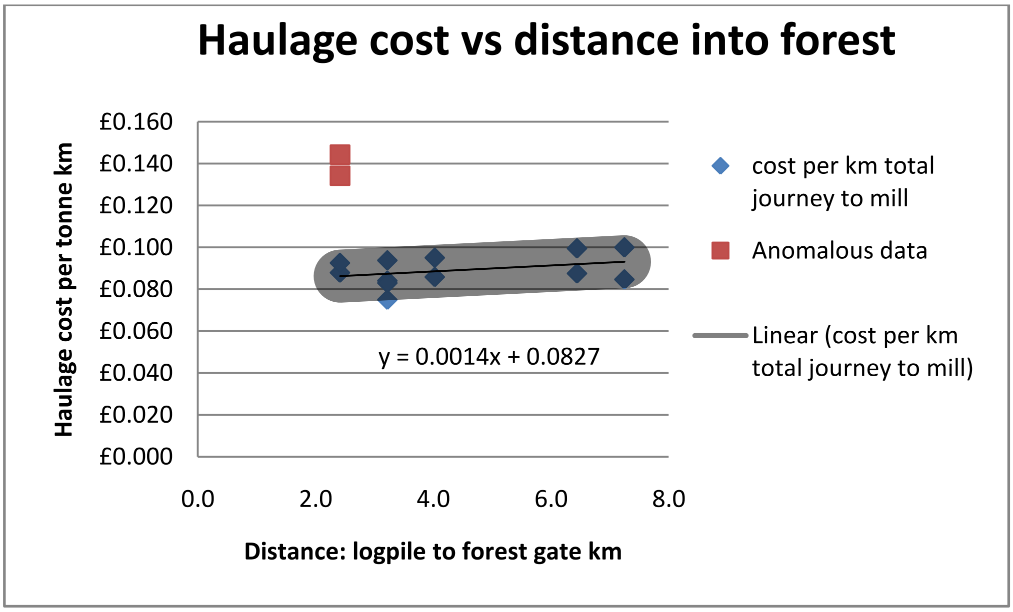
Suggested reasons for this anomaly are:

- The quoted current RHA rates may be generous
- The true market cost of timber haulage may not be as high as the 80% premium suggested in the FE/SE report.
- Market forces may be driving timber transport rates below sustainable levels

A similar exercise was carried out on the Processor figures described in the main report and these gave an average rate of 11.6p per tonne-km. Assuming again a 25t payload this gives a total charge of £2.90 per km (£4.67 per mile) and a cost per running km (mile) of £1.45 (£2.33). This rate is 22% above the Highland rate and is only slightly below the FE/SE forest haulage rate. This would appear to validate the latter rate and suggest that the Highland rate may not be sustainable.

In-Forest Haulage Rates

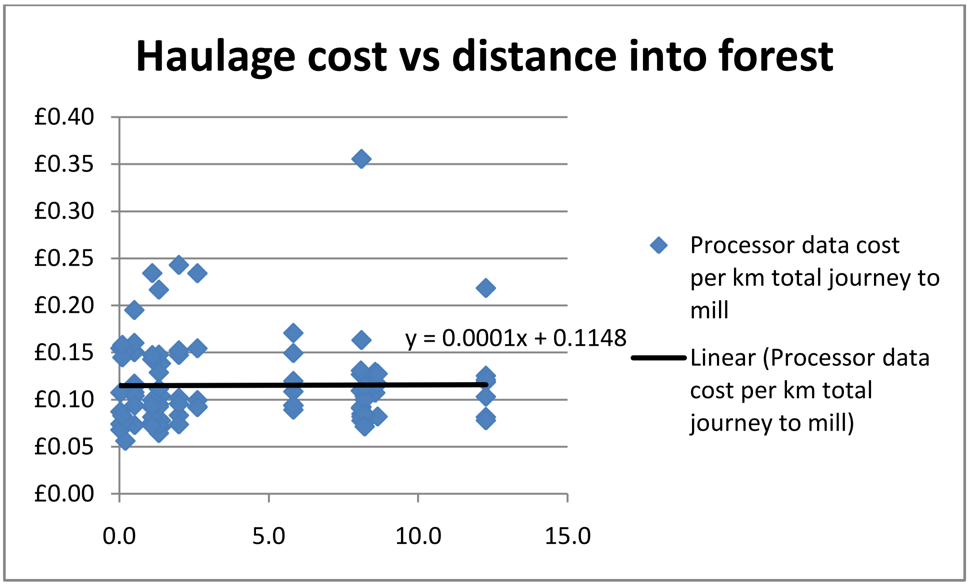
Within the Highland data the distance travelled in-forest varied from 2.4 to 7.2km (1.5 to 4.5 miles) and the following graph shows the haulage cost for the total journey per tonne km versus the distance travelled into the forest. Two of the data points have been discarded as being anomalous, because they related to the shortest total journeys.



The trend line suggests a slight increase in total journey cost as timber is extracted from deeper forests. Although the slope is slight it indicates an increase in the total journey rate of 1p per tonne km, when the journey extends 7km into the forest. Assuming a typical 80km journey to the mill this generates an extra 80p in revenue per tonne. If it is reasonably assumed that this increased cost derives from the increased difficulties of the 7km in-forest it amounts to an extra 11p to be added to the basic average rate of 9.5p. This would suggest that the rate for the in-forest haulage might be 20.5p per tonne km, roughly double the value for running on the road.

A high degree of caution must be exercised in view of the limited data available, but the above does fit well with anecdote and intuition.

A similar exercise was carried using the Processor data described in the main body of the report. This provided 97 data points with in-forest journeys of 0-12km, in total journeys of up to 160km, and might have been expected to deliver a robust result. Unfortunately this graph shows only too well the problem of scatter, confirming again that there are too many variables impacting on the cost equation to enable simple conclusions to be drawn. Indeed the trend line is almost level suggesting perversely that there is no increase in overall cost as journeys go deeper into the forest, and negating the above analysis of the Highland figures.



LGP Vehicle Costs

Because of commercial confidentiality the actual cost of the JST LGP vehicle is not known, and the following assumptions have been made to inform the analysis.

The LGP truck carries 45t compared to the 25t of a conventional artic. Fuel consumption on dedicated in-forest activity is extremely high but this is significantly offset by the 39% saving made by the use of rebated fuel. The total running cost per km of the much bigger LGP truck is clearly no less than that of an artic doing the same journey although it is reasonable to deduce that the rate per tonne will be less.

Assumed Comparative Vehicle Costs

Neither the Highland data nor the Processor data shows the step-change in the total journey rate that might be expected when an artic goes deeper in-forest, at least not up to the 12km covered by the data available. This is counter-intuitive and contrary to anecdote as it must be more expensive to run an artic deep into the forest compared to a run on the margin. The lack of clear evidence of a rate rise may be due to the scatter in the data or as a result of market forces. Perhaps hauliers spread some of the risk and higher cost onto other jobs.

In-forest rates of 150-200% of the road rate are quoted anecdotally and the higher value has been chosen as the minimum forest rate in the table below. This rate cannot be considered excessive as it would only yield the haulier a modest extra £1 per tonne on a 10km forest leg, when compared to normal road rates. Indeed such an increase is readily obscured in the +/- £1.75/tonne data scatter discussed in the main report.

Only one set of rates for in-forest haulage by LGP vehicle was available for this study. The detail of these rates is subject to confidentiality but indicates the cost per mile travelled may be significantly higher than assumed below. However if this higher rate is used, it can reasonably be argued that the rate for the artic operating in-forest would have to be increased in parallel, as the cost per tonne on the specialist vehicle using rebated fuel should always be lower. The impact of these higher rates is discussed in the main report.
For the purposes of this study the figures in the following table have been assumed.

Vehicle	Journey	Cost ***per km (mile) travelled*** (£)	Cost ***per tonne-km charged one way*** (p)	Explanation
Artic, 25t payload	Mainly public road, unloaded one way	1.20 (1.92)	9.5	Cost per tonne km supported by Highland rates
Artic, 25t payload	Mainly in-forest, unloaded one way	2.40 (3.84)	19.0	Assumes deeper in-forest working is double the cost of road working
LGP vehicle, 45t payload	Entirely in-forest, unloaded one way	3.40 (5.44)	15.1	Assumes rate per tonne is less than the artic, given rebated fuel and relaxed drivers hours
Artic, 29t payload (skeletal trailer or no crane)	Entirely public road, unloaded one way	1.20 (1.60)	8.2	Same basic cost as road-going artic, but greater payload reduces unit cost per tonne