LOGGING INDUSTRY RESEARCH ASSOCIATION

NEW ZEALAND

PROJECT REPORT

— LOG TRUCK AXLE LAYOUTS —

(An economic comparison of 5-axle and 6-axle layouts)

P.R. 10 1980

N.Z. LOGGING INDUSTRY RESEARCH ASSOCIATION (INC.)

P.O. Box 147 Rotorua New Zealand

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Project Report No. 10
1980

- LOG TRUCK AXLE LAYOUTS -

(An economic comparison of
5-axle and 6-axle layouts)

P.R. 10 1980

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- S U M M A R Y -

Payload size is an important factor influencing log transport costs. It is determined basically by the axle layout* of the log truck unit. A wide range of options exist for axle layout with most in New Zealand being various 5-axle and 6-axle layouts, the most common being a 5-axle layout. This study was thus aimed at comparing the economics of different 5-axle and 6-axle layouts.

Information on capital costs, tare weights, weight restrictions and operating costs for different layouts were obtained from a range of industry sources. A detailed analysis of modelled operating costs and payload carrying abilities was then carried out so that comparable log cartage costs could be derived. The practicality of the various layout options is briefly covered, and finally the best layouts for different applications is described in the concluding section.

The study indicates that for N.Z. on-highway operation some of the not so commonly used layouts (mainly with 6-axles) offer economic advantages over the present most common layout (which comprises a 3-axle truck with a 2-axle trailer). The economic advantages are very significant where the operation is restricted by Class II road limits.

* The term "axle layout" is used throughout this report to reflect the configuration of axles, or the relative spacing of axles.

- A C K N O W L E D G E M E N T S -

Information used in this study was supplied by; the trailer manufacturers, Jack Tidd-Ross Todd Limited, Mills-Tui Trailers Limited, Road Runner Trailers Limited and Domett Fruehauf Trailers Limited; as well as the logging operations of N.Z. Forest Products Limited and Carter Oji Kokusaku Pan Pacific Limited.

A costing technique developed by the N.Z. Road Transport Association was used in modified form and was the basis of the economic comparison.

- TABLE OF CONTENTS -

- LIST OF FIGURES -

- LIST OF TABLES -

- 1 -

INTRODUCTION

1.1 BACKGROUND:

LIRA's 1977/78 log trucking studies indicated that payload size was one important factor that influenced log transport costs (1).

The N.Z. log transport industry is strongly dependant on 5-axle log truck layouts for log transport (70% of all units), the most common layout being a 3-axle truck with a 2-axle log trailer. The majority of trucks in N.Z. are set up for carting long length logs (8 m to 15 m) with most of the remainder being short log (up to 6 m) cartage units (1).

Figure 1. Most Common N.Z. Log Truck Layout - 3-axle Truck with 2-axle (2.4 m spaced) Trailer.

On N.Z. highways 5-axle layouts are restricted to lower gross weight limits than 6-axle layouts and they thus achieve lower payload sizes. The 5-axle layouts, however, generally cost less to purchase and operate than 6-axle layouts although they do operate with a higher Road User Charges rate.

The objective of the study was thus to compare the economics of different 5-axle and 6-axle

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(1)- "Log Trucking Studies - Identification of Suitable Research Areas" by R.D.Gordon. LIRA Project Report No. 7, 1978.

layouts and to identify the benefits of each axle configuration, such that future development of the industry can consider the alternatives.

1.2 METHOD:

To compare the economics of the different layouts comparative log cartage costs were compiled from the operating costs and payload capacities. This was achieved by modelling the operating costs and payload capacities using detailed information gained from industry. Comparative log cartage costs were then calculated for a typical average N.Z. log truck application.

The analysis was initially carried out for long log (8 m to 15 m) cartage units and then extended to include short log cartage units. To check on the practicality of what seemed to be more economic axle layouts a brief discussion of some of the various axle layout features was then included.

1.3 ASSUMPTIONS:

Important basic assumptions were made so that the modelled costs and payload capacities for the different layouts were truly comparable, these being as follows:

1. All truck units whether 2-axle, 3-axle or 4-axle are 216 kw (290 hp) size in the Leyland, Mercedes category, with 35 to 40 tonnes gross combination weight ratings.

2. Cost, weight and other data used in the analysis is relevant to July/August, 1979, with estimates being based on surveys and updated past figures.

3. All trucks cover 80,000 km per year with the average payload haul distance being 40 km and trucks achieving 4 loads per day over 240 days per year.

4. Three-quarters of all running is on highway (for on-highway operations) and the rear trailer is piggy-backed for half the annual mileage.

A number of other assumptions are made in the analysis and these are noted in the calculations shown in the Appendix section.

COMPARATIVE LAYOUT ECONOMICS

The results of the analysis are shown in Tables 1 and 2 for long-log cartage rigs and Tables 3 and 4 for short-log cartage rigs. The calculation detail for each is shown in Apendices I and II.

The most notable points are as follows:

1. Between layouts no significant difference occurs in total annual rig operating costs, as the sheer size of the truck operating cost element tends to overshadow the differences in trailer operating costs (including trailer Road User Charges) that are achieved through different trailer options. Truck operating costs form from 80% to 90% of total operating costs.

2. Legal payload carrying ability on-highway is influenced more significantly than the rig operating costs, through changes to the axle layout. The variation in payload carrying ability is also more significant for Class II road operations than Class I operations.

3. Log cartage costs per tonne are influenced by rig layout and on highway the 6-axle rigs generally give a slightly lower log cartage cost than 5-axle rigs. On 100% off-highway work, however, 5-axle rigs give a lower log cartage cost than 6-axle rigs.
   NOTE: The relative economics (compared log cartage costs) of the different axle layouts is not sensitive to typical variations in annual mileage achieved. The indications of "best layouts" are thus applicable no matter what the annual truck mileage.

From the Tables 1, 2, 3, 4 the results are further summarised separately for long-log and short-log layouts in the following subsections. The economics of modifying current layouts is considered as well as the economics of the long semi-trailers ("Bailey Bridges") which are capable of carrying either short logs or long logs.

TABLE 1. TABULATED RESULTS - COSTS (LONG LOG LAYOUTS)

ITEM	LOGGING RIG CONFIGURATION	PURCHASE COSTS ($)		TRUCK OPERATING COSTS PER YEAR ($)		TRAILER UNITS - OPERATING COST PER YEAR ($)						TOTAL RIG OPERATING COST ($) PER YEAR
						STANDING COSTS			RUNNING COSTS			
		TRUCK UNIT	TRAILER UNITS	STANDING COSTS	RUNNING COSTS *	DEPREC-IATION	INSUR. & REGISTRA.	INTEREST	REPAIRS & MAINT.	TYRES	ROAD USER CHG.	
A		85000	10925	34213	37596	1092	414	819	1785	2000	1453	79372
B		85000	11820	34213	37596	1182	441	886	1785	2000	1827	79930
C		85000	11945	34213	37596	1194	444	896	2255	2000	2719	81317
D		75000	19475	32684	32772	1947	753	1461	3031	3250	4895	80793
E		85000	15550	34213	36936	1555	552	1166	3000	3000	1653	82075
F		85000	19475	34213	35076	1947	753	1461	3031	3250	4068	83799
G		91500	11945	35209	39240	1194	444	896	2255	2000	2719	83957
H		92500	11945	35361	38488	1194	444	896	2255	2000	2719	83357

TABLE 2. TABULATED RESULTS - PAYLOADS (LONG LOG LAYOUTS)

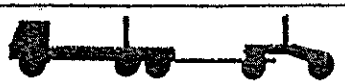
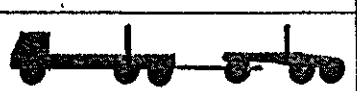
ITEM	LOGGING RIG CONFIGURATION	GROSS WEIGHT LIMITS FOR RIG (TONNES)			TARE WEIGHTS (TONNES)		PAYLOADS (TONNES)			LOG CARTAGE COSTS (DOLLARS PER TONNE)		
		OFF-HIGHWAY	CLASS I	CLASS II	TRUCK UNIT	TRAILER UNITS	OFF-HIGHWAY	CLASS I	CLASS II	OFF-HIGHWAY	CLASS I	CLASS II
A		45.0	34.4	30.0	9.2	3.0	32.8	22.2	17.8	2.24*	3.58	4.46
B		45.0	35.4	31.0	9.2	3.2	32.6	23.0	18.6	2.26*	3.48	4.30
C		45.0	36.3	32.1	9.2	3.5	32.3	23.6	19.4	2.30*	3.45	4.19
D		45.0	38.2	34.2	7.8	5.6	31.6	24.8	20.8	2.27*	3.26	3.88
E		45.0	39.0	36.5	9.2	4.8	31.0	25.0	22.5	2.47*	3.28	3.65
F		45.0	39.0	39.0	9.2	5.6	30.2	24.2	24.2	2.58*	3.46	3.46
G		45.0	39.0	34.6	10.5	3.5	31.0	25.0	20.6	2.52*	3.36	4.08
H		45.0	39.0	37.1	10.0	3.5	31.5	25.5	23.6	2.46*	3.27	3.53

TABLE 3. TABULATED RESULTS - COSTS (SHORT LOG LAYOUTS)

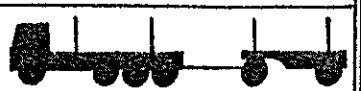
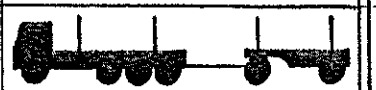
ITEM	LOGGING RIG CONFIGURATION	PURCHASE COSTS ($)		TRUCK OPERATING COSTS PER YEAR ($)		TRAILER UNITS - OPERATING COST PER YEAR ($)						TOTAL RIG OPERATING COST ($) PER YEAR
						STANDING COSTS			RUNNING COSTS			
		TRUCK UNIT	TRAILER UNITS	STANDING COSTS	RUNNING COSTS *	DEPREC-IATION	INSUR. & REGISTRA.	INTEREST	REPAIRS & MAINT.	TYRES	ROAD USER CHG	
A		85000	12485	34213	37596	1248	459	936	2255	2000	2719	81426
B		75000	20015	32684	32772	2001	722	1501	3031	3250	4895	80856
C		75000	15945	32684	32772	1594	564	1196	3000	3000	2303	77112
D		75000	23475	32684	32772	2347	824	1760	3776	4250	2511	80924
E		85000	15945	34213	36936	1594	564	1196	3000	3000	1653	82156
F/		85000	20015	34213	35076	2001	722	1501	3031	3250	4068	83862
G		91500	12485	35209	39240	1248	459	936	2255	2000	2719	84066
H		92500	12485	35361	38488	1248	459	936	2255	2000	2719	83466
I		75000	24970	32684	32772	2497	869	1873	4040	4000	3171	81906

TABLE 4. TABULATED RESULTS - PAYLOADS (SHORT LOG LAYOUTS)

ITEM	LOGGING RIG CONFIGURATION	GROSS WEIGHT LIMITS FOR RIG (TONNES)			TARE WEIGHTS (TONNES)		PAYLOADS (TONNES)			LOG CARTAGE COSTS (DOLLARS PER TONNE)		
		OFF-HIGHWAY	CLASS I	CLASS II	TRUCK UNIT	TRAILER UNITS	OFF-HIGHWAY	CLASS I	CLASS II	OFF-HIGHWAY	CLASS I	CLASS II
A		45.0	36.3	32.1	9.2	3.8	32.0	23.3	19.1	2.32*	3.49	4.26
B		45.0	38.2	34.2	7.8	6.2	31.0	24.2	20.2	2.32*	3.34	4.00
C		45.0	35.1	31.3	7.8	5.0	32.2	22.3	18.5	2.20*	3.46	4.17
D		45.0	39.0	38.6	7.8	7.4	29.8	23.8	23.4	2.50*	3.40	3.46
E		45.0	39.0	36.5	9.2	5.0	30.8	24.8	22.3	2.49*	3.31	3.68
F		45.0	39.0	39.0	9.2	6.2	29.6	23.6	23.6	2.63*	3.55	3.55
G		45.0	39.0	34.6	10.5	3.8	30.7	24.7	20.3	2.55*	3.40	4.14
H		45.0	39.0	37.1	10.0	3.8	31.2	25.2	23.3	2.49*	3.31	3.58
I		45.0	39.0	39.0	7.8	7.2	30.0	24.0	24.0	2.49*	3.41	3.41

2.1 NEW LONG LOG CARTAGE LAYOUTS:

The following table summarises the cartage cost differences in relation to the current most common layout (i.e. 3-axle truck with 2-axle, 2.4m spaced, trailer).

TABLE 5 : COMPARISON OF CARTAGE COSTS BY DIFFERENT LONG-LOG LAYOUTS

LIMITED BY CLASS I CARTAGE	CARTAGE COST (DOLLARS / TONNE)	ADVANTAGE OVER MOST COMMON RIG
	3.45	Most common rig
	3.26	6% saving
	3.27	5% saving
	3.28	5% saving
	3.36	3% saving
	3.46	Nil saving
LIMITED BY CLASS II CARTAGE	**CARTAGE COST (DOLLARS / TONNE)**	**ADVANTAGE OVER MOST COMMON RIG**
	4.19	Most common rig
	3.46	18% saving
	3.53	16% saving
	3.65	13% saving
	3.88	7% saving
	4.08	3% saving

TABLE 5 CONT.

LIMITED BY OFF-H/W CARTAGE	CARTAGE COST (DOLLARS / TONNE)	ADVANTAGE OVER MOST COMMON RIG
	2.30	Most common rig
	2.24	7% saving
	2.26	2% saving

This indicates that where new layouts are to be built for long log cartage serious consideration snould be given to the following which offer cartage cost advantages over the present most common 5-axle layout. The cartage cost savings are of the order of approximately 5% for Class I operation and approximately 15% for Class II operation.

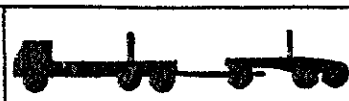
APPLI-CATION	LAYOUTS WITH BEST ECONOMICS		
CLASS I			
CLASS II			

TABLE 6 : LONG-LOG LAYOUTS WITH BEST ECONOMICS

2.2 MODIFYING CURRENT LONG-LOG CARTAGE LAYOUTS:

During 1977, approx. 59% of all units were 5-axle long-log cartage layouts.(1) It was thus considered important to look at the possibilities of modifying these to the seemingly more economical layouts.

A summary of the estimated annual savings achievable by modifying the currently most common 5-axle layout is tabulated below along with the estimated time over which the modification would pay for itself.

(1)- "Log Trucking Studies - Identification of Suitable Research Areas" By R.D. Gordon. LIRA Project Report No. 7, 1978.

MOST COMMON RIG → 				CLASS I OPERATION	
ALTERNATIVE MODIFICATIONS TO MOST COMMON RIG ↓	CARTAGE COST SAVINGS ($/TONNE)	CLASS I PAYLOAD (TONNES)	ANNUAL SAVINGS (over 1000 trips)	ESTIMATE COST OF MODIFIC-ATION (1)	TIME TO PAY FOR MODIFIC-ATION
	0.17	25.0	$4250	$5300	15 mths
	0.18	25.5	$4590	$10000	26 mths
	0.09	25.0	$2250	$6500	35 mths
	Nil	24.2	Nil	$9000	Won't pay

MOST COMMON RIG → 				CLASS II OPERATION	
ALTERNATIVE MODIFICATIONS TO MOST COMMON RIG ↓	CARTAGE COST SAVINGS ($/TONNE)	CLASS II PAYLOAD (TONNES)	ANNUAL SAVINGS (over 1000 trips)	ESTIMATE COST OF MODIFIC-ATION (1)	TIME TO PAY FOR MODIFIC-ATION
	0.54	22.5	$12150	$5300	5 mths
	0.73	24.2	$17666	$9000	6 mths
	0.66	23.6	$15576	$10000	8 mths
	0.11	20.6	$2266	$6500	34 mths

TABLE 7 : MODIFYING CURRENT LONG-LOG LAYOUTS

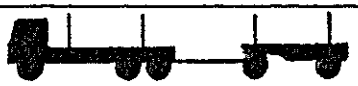
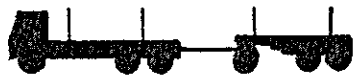
The best modification to the current most common layout, where being used on both Class I and Class II roads, is to convert the 2-axle trailer to a 3-axle trailer. However, where operation is restricted by Class II limits entirely, then the best modification is to add a single axle dolly between truck and trailer.

2.3 NEW SHORT LOG CARTAGE LAYOUTS:

The following table summarises the cartage cost differences in relation to the current most common layout (i.e. 3-axle truck with 2-axle trailer).

(1) - Personal communications with various truck and trailer manufacturers, 1979.

TABLE 8 : COMPARISON OF CARTAGE COSTS BY DIFFERENT SHORT-LOG LAYOUTS

LIMITED BY CLASS I CARTAGE	CARTAGE COST (DOLLARS/TONNE)	ADVANTAGE OVER MOST COMMON RIG
	3.49	Most common rig
	3.31	5% saving
	3.31	5% saving
	3.34	4% saving
	3.40	3% saving
	3.40	3% saving
	3.41	2% saving
	3.46	1% saving
	3.55	Nil saving
LIMITED BY CLASS II CARTAGE	**CARTAGE COST (DOLLARS/TONNE)**	**ADVANTAGE OVER MOST COMMON RIG**
	4.26	Most common rig
	3.41	20% saving
	3.46	19% saving
	3.55	17% saving
	3.58	16% saving
	3.68	14% saving
	4.00	6% saving
	4.14	3% saving
	4.17	2% saving

This indicates that where new layouts are to be built for short log cartage, serious consideration should be given to the following which offer cartage cost advantages over the present most common 5-axle layout. Like the long log layouts, the cartage cost savings are of the order of approximately 5% for Class I operation and approximately 15% for Class II operation.

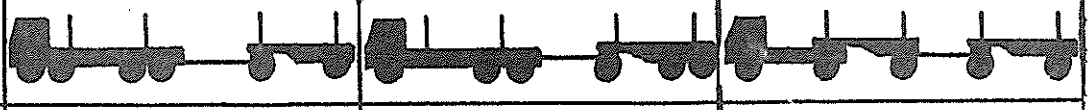
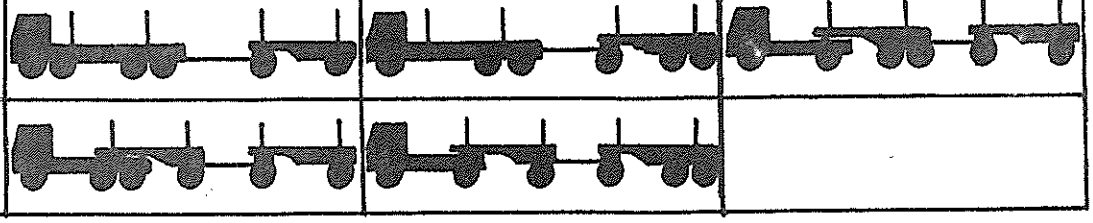
APPLI-CATION	LAYOUTS WITH BEST ECONOMICS
CLASS I	
CLASS II	

TABLE 9 : SHORT-LOG LAYOUTS WITH BEST ECONOMICS

2.4 COMMENT ON SHORT OR LONG-LOG SEMI-TRAILERS:

Semi-trailer units which are capable of carrying either short or long logs and locally referred to as "Bailey Bridge" trailers, are appearing in small numbers in some New Zealand areas.

Figure 2. "Bailey Bridge" Semi-trailer Type Layout - Long or Short Logs

A major reason for their introduction is that they provide a much more versatile log transport unit. Not only is this log trailer capable of carrying either short or long logs, but the truck unit can be readily applied to pulling any other semi-trailer with its fifth wheel attachment. These features are obviously becoming increasingly important as they can provide for better utilisation of high capital cost equipment.

They do have their disadvantages though, which in the main are associated with the long trailer chassis. They have a higher tare weight which reduces payload , the purchase cost is higher, and turning on small landings is often difficult.

As log cartage costs are very sensitive to payload size, it was considered important to compare the Bailey Bridge concept with conventional long-log and short-log cartage layouts. Using the cost modelling technique of this study, comparative cartage costs for the Bailey Bridge layout were derived (see Appendix III), and compared with long-log and short-log layouts as follows:

AXLE LAYOUT	CARTAGE COSTS (DOLLARS/TONNE)	
	CLASS I	CLASS II
(Long-log layout) 	3.28	3.65
(Short-log layout) 	3.31	3.68
(Bailey Bridge layout) 	3.91	4.42

TABLE 10 : COMPARISON OF LONG-LOG, SHORT-LOG, & BAILEY BRIDGE LAYOUTS

The comparison indicates that short-log layouts cart logs at approximately 1% to 2% more cost than long-log layouts, and that Bailey Bridge layouts cart logs at approximately 20% more cost than long-log layouts, (for on-highway operation).

The need to use Bailey Bridge semi-trailer type layouts should thus be carefully analysed as they undoubtedly cart logs at a much higher cost in an on-highway operation .

- 3 -

PRACTICALITY OF ALTERNATIVE LAYOUTS

While a simple economic comparison may indicate the desirability of using not so common layouts, other important aspects also need consideration, such as:

1. The suitability of twin-steer 4-axle trucks in forest conditions.
2. The suitability of 3-axles in the drive-set of a truck.
3. The perfomance achievable with a single drive-axle truck.
4. Operation with dolly or semi-trailer units between truck and trailer.
5. The influence of heavier 3-axle trailers.

This section briefly discusses some of these issues.

3.1 TWIN-STEERING TRUCK UNITS:

Twin-steer units are in use as log trucks in New Zealand on numerous truck brands such as Kenworth, International, Leyland, and E.R.F. A 1977 LIRA survey (1) showed 3% of all trucks had twin-steer axles, and all of these were short log cartage rigs.

Figure 3. Twin-steer Truck Unit - A Short Log Rig

(1) - "Log Trucking Studies - Identification of Suitable Research Areas" by R.D. Gordon. LIRA Project Report No.7, 1978

Opinions on their suitability in logging as expressed by twin-steer operators is, however, very diverse with some for and some against their suitability. Discussion during a LIRA log transport Seminar(1) indicated the following:

Better truck stability with twin-steer.
Opposed opinions as to whether sledging was more prevalent.
Safety advantages if a front tyre failed with twin-steer.
Opposed opinions on tyre wear.

Enquiries made with N.Z. truck suppliers who have supplied twin-steer units resulted in the following opinions. Modern twin-steer units, where properly engineered to give accurate steering geometry in all situations and to give matched characteristics between the two steering axles (including suspension, steering, balance, etc.), perform just as well in terms of sledging and tyre wear as single-steer units, in the correct application.

On a long log rig, to get the payload advantages out of a twin-steer unit, the bolster offset needs to be greater than without twin-steer. This also improves resistance to sledging, improves resistance to jack-knifing, improves manoeuverability and ride.(2) It does,however, impose greater point loading stresses on the chassis (if the bolster is not positioned forward to get weight on the front axles then sledging will become more probable).

Most overseas literature indicates the twin-steer unit used as a rigid vehicle rather than an articulated vehicle; thus it would seem suited to short-log cartage, rather than long-log cartage or semi-trailer use, where possibly its use needs careful engineering.

A further restriction with twin-steer units is that they are only suitable for cab-over-engine type trucks.

3.2 3-AXLE DRIVE SETS:

These are in use in New Zealand on a very small number of log trucks, mainly short-log cartage units, and all involve an extra non-driven or lazy axle added to the tandem-drive group.

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(1) - "Log transport and Loading Seminar Proceedings" by R.D. Gordon LIRA Project Report No. 8, 1979 .

(2) - "Trucks and Trailers and Their Application to Logging Operations" by J.A. McNally, published by University of New Brunswick.

Figure 4. Three Axles in the Drive-set - Lazy Axle with Tandem Drive

They are not common overseas and their use in New Zealand has not shown up any major performance problems. Additional tyre wear on such layouts does not seem to be a significant factor. A quote during the LIRA Seminar (1) stated that vehicles spent more than 94% of their running time actually travelling in straight lines and this would not add to tyre wear.

3.3 SINGLE DRIVE-AXLE TRUCKS:

Single drive-axle trucks were in relatively common use during the earlier days of New Zealand's log trucking. With the development and introduction of tandem drive-axles they were rapidly replaced due to the problems they caused on forest roads. They were considered to do more damage to road surfaces and more readily got into traction difficulties. Only a very small number are in current use in New Zealand as log trucks, however, their use for strictly on-highway (sealed) trucking is common in such vehicles such as chip trucks and post cartage trucks pulling semi-trailers.

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(1) - "Log Transport & Loading Seminar Proceedings" by R.D.Gordon - LIRA Project Report PR8, 1979

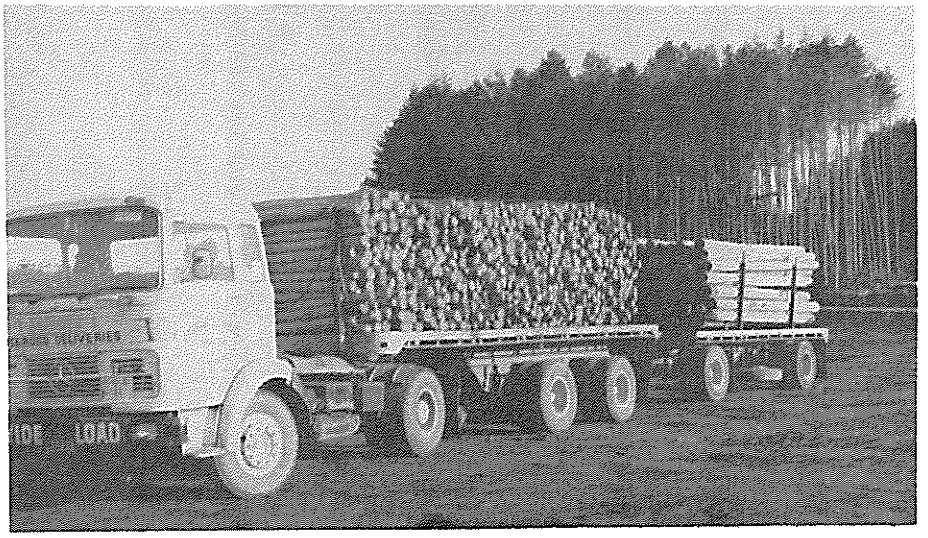

Figure 5. Single Drive-axle Truck Unit - Post Cartage on Highway

It is considered that where a log trucking operation involves sealed road running only, such as from Mill to Export Port, then the single drive-axle truck should perform without difficulties.

3.4 DOLLY OR SEMI-TRAILER UNITS:

Single-axle dolly units between truck and rear trailer have become relatively common on long-log cartage rigs in New Zealand over recent years. Their forest performance is well proven and no problems exist in getting suitable weight distribution or in carrying 2-axle trailers.

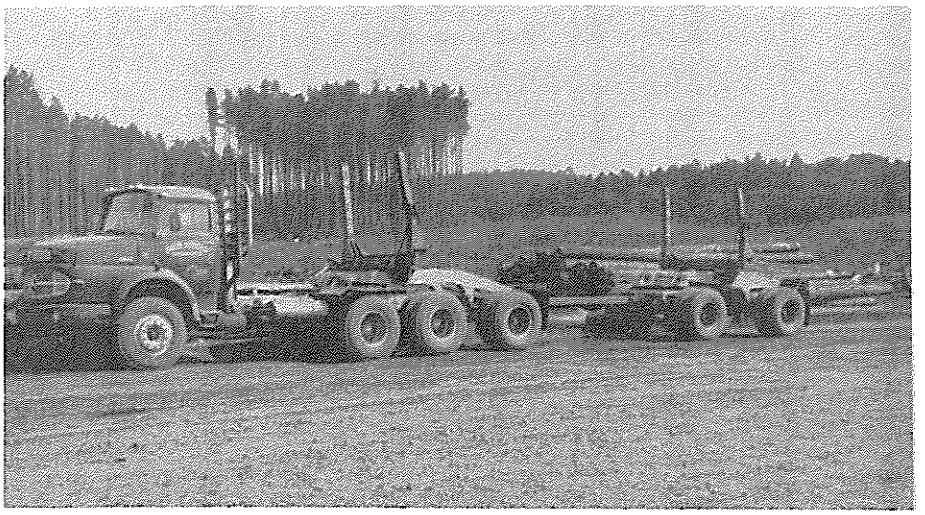

Figure 6. Single-axle Dolly Between Truck and Trailer - Long Log Unit

For short-log cartage both single-axle and 2-axle semi-trailers are used satisfactorily between truck and trailer, by a small number of operators. Again 2-axle short-log trailers can be carried but 3-axle short-log trailers only seem to be carried on 2-axle semi-trailers.

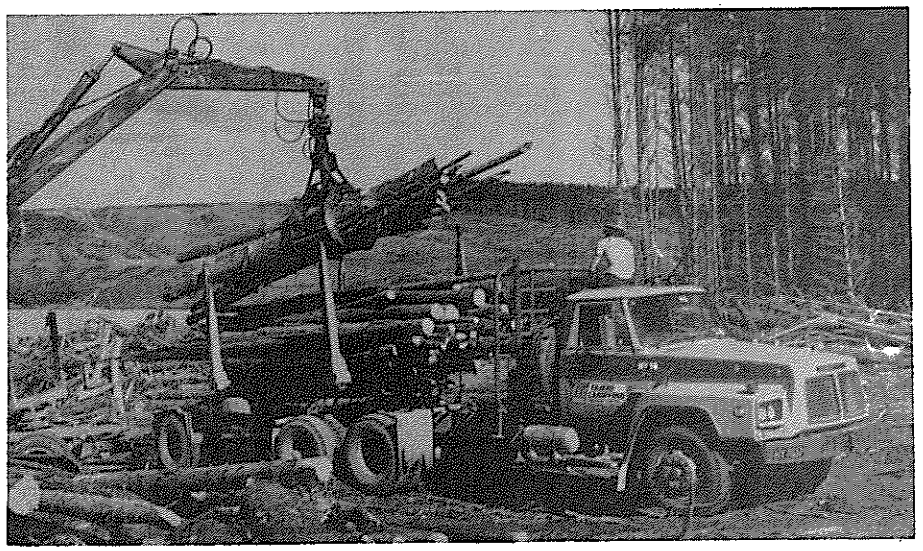

Figure 7. Single-axle Semi-trailer on Truck - A Short Log Unit

An important advantage of a dolly or semi-trailer unit is that because of the fifth-wheel coupling to truck unit it readily lends itself to pre-loading a staked-out trailer, and also makes the truck unit readily applicable to other cartage operations which is important in contractor situations.

3.5 3-AXLE LOG TRAILERS:

3-axle trailers have for sometime been in use successfully throughout New Zealand as both short-log full-trailers and long-log jinker trailers. More recently with the introduction of Road User Charges their numbers have increased. Their forestry performance is well proven and they can readily be carried on the truck units, but their New Zealand use has come up against the following two problems.

Figure 8. Three-axle Long-log Jinker Trailer - Piggy-Backed Position

Figure 9. Three-axle Short-log Full Trailer

1. The New Zealand long-log 3-axle jinkers traditionally have the two close-axles at the rear. This results in the trailer bolster being closer to the rear for correct weight distribution and thus the distance between the truck and trailer bolsters is extended. A difficulty then evolves on some units in that they have problems fitting 8 m export logs safely onto the unit between the truck and trailer bolsters.

A 3-axle jinker with the two close-axles to the front would not have this difficulty. Although not yet tried in New Zealand such units have been recently introduced into B.C., Canada. (There have been a small number of 3-axle shorts trailers used in New Zealand with the two close-axles to the front and users indicate they present no problems.)

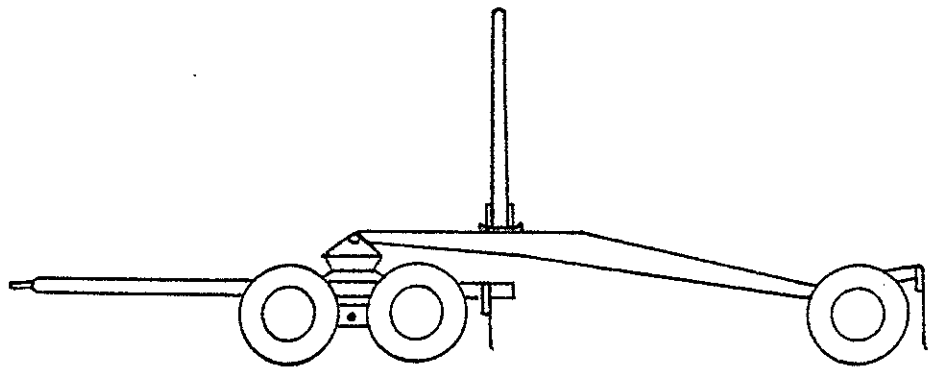

Figure 10. Alternative 3-axle Log Trailer as Used in Canada

The Canadian arrangement differs in concept from the New Zealand jinkers in that they are made up using a conventional close-axle jinker from which the bolster is removed. The bolster is fitted to a trailing frame with single axle which hitches and locks into the 2-axle jinker's bolster cup and saucer. It is thus a very versatile arrangement suited to 2-axle off highway use or 3-axle on highway use.

2. 3-axle trailers are much heavier than 2-axle trailers and in some areas the commonly used rubber-tyred front-end log loaders can not off-load them from the piggy-backed position on trucks. This has resulted in larger rubber-tyred front-end loaders being brought into operation.

   Discussions with rubber-tyred front-end loader operators indicate that loaders in the 75 kW (100 hp) class (e.g. Fiat Allis 605, Cat 930, Clark 55) can off-load 2-axle trailers but not 3-axle trailers. These required a loader in the 100 kW (140 hp) class (e.g. Fiat Allis 645, Cat 950, Clark 75) although even this size loader can have some problems with heavier 3-axle short-log full-trailers.

It should be noted that trailers capable of being off-loaded from a truck without using a loader are in common use in some overseas areas, although only on 1 or 2-axle jinkers. The method usually involves a hinged, folding pole, as shown in Figure 11. It works very successfully. Potential exists to explore the possibility of using a similar method with a 3-axle trailer, particularly the Canadian type (Figure 10), where possibly the rear trailing axle need not be piggy-backed but could remain trailing, as depicted in Figure 12.

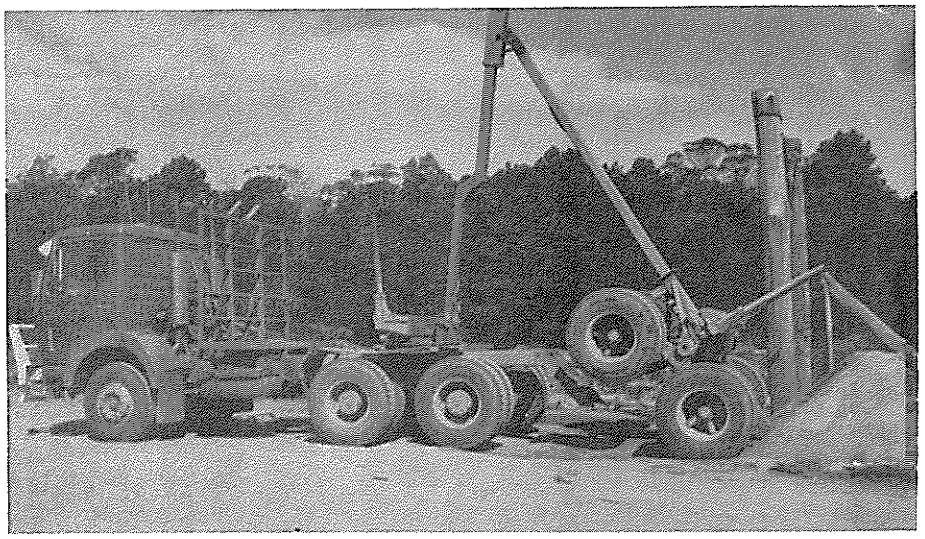

Figure 11. Self-dropping Log Jinker as Used in Australia

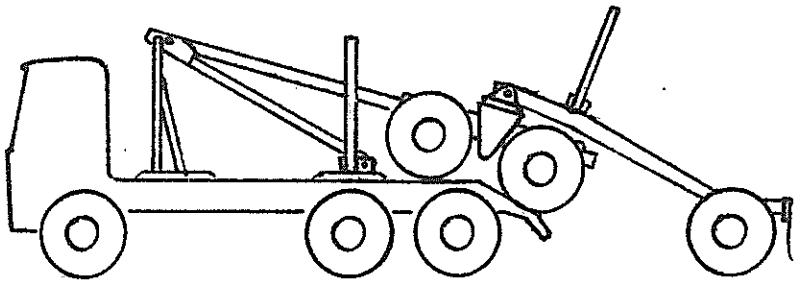

Figure 12. Possible Self-dropping 3-axle Trailer Layout

- 4 -

CONCLUSIONS

This study has aimed to compare 5-axle and 6-axle log truck layouts. It shows that differences in axle layouts cause differences in cartage costs, in the main through the resultant change in payload capacity rather than the resulting change in operating costs which are comparatively small.

The economic comparison and considerations of layout practicality indicate that the current most common layout of 3-axle truck with 2-axle trailer is not the best option for highway work. It is undoubtedly the simplest log transport layout but others in both short-log rigs and long-log rigs offer potential cost savings. The cartage cost savings available are of the order of 5% on Class I operation and 15% in Class II operation.

As some 6-axle layouts on Class II road limits still don't achieve the maximum gross weight limit of 39 tonnes, the economics of 7-axle layouts should be investigated for operations solely restricted to Class II limits. Such layouts, however, would be at a significant disadvantage for Class I operation and are thus probably not good versatile units.

For on-highway long-log cartage the 3-axle truck with 3-axle trailer should be seriously considered although where the rig is working under Class II road restrictions solely, then the 3-axle truck with single-axle dolly and 2-axle trailer is best, (this layout, however, offers no savings under Class I operation). The off-loading of 3-axle trailers in the bush, however, requires a larger log loader and the economics of different operations may or may not support this. Some thought should be given to the self-dropping trailer concept as mentioned in Section 3.5 of this Report, as this seems worthy of investigation. Twin-steer 4-axle trucks with 2-axle trailers, although economically competitive on paper are not recommended for long-log cartage due to the nature of the loading and engineering required on such units. In the likelihood of a cartage operation that involves 100% Class I sealed road use, such as Mill to Export Port, then the 2-axle truck (single drive-axle) with single axle dolly and 2-axle trailer can also be considered.

For strictly off-highway long-log cartage the 3-axle truck with 2-axle jinker trailer is best out of the 5-axle and 6-axle rigs available.

For on-highway short-log cartage the twin-steer 4-axle truck with 2-axle shorts trailer is recommended, the twin-steer configuration being well suited to shorts application due to the nature of the chassis loading which is significantly different to that on long-log rigs. As well the 3-axle truck with 3-axle shorts trailer should be equally considered although the heavier 3-axle trailer would pose difficulties for some bush loaders to off-load. As for long-log cartage rigs where operation is solely on Class II limits then the 3-axle truck with 1-axle shorts semi-trailer and 2-axle shorts trailer is recommended, and where operation involves 100% Class I sealed road use then the 2-axle truck with 1-axle shorts semi-trailer and 2-axle shorts trailer can be considered.

Bailey Bridge type semi-trailers that can cart either short logs or long logs should only be used where economics of the overall operation allow it. For on-highway operation they result in log cartage costs approximately 20% higher than if using conventional short-log units or conventional long-log units. Efficient control of truck utilisation (particularly through scheduling), should negate the need for large numbers of Bailey Bridge type semi-trailers.

CALCULATION DETAIL - LONG-LOG CARTAGE LAYOUTS

The basic assumptions as listed in Section 1.3 are used, as well as the following references:

"1979 Truck Specs. Reference Issue"
A Transport News Journal schedule of truck specifications and costs.

"Log Transport and Loading Seminar Proceedings"
Section VIII (b). LIRA Project Report No. 8, 1979.

"Log Cartage Cost Index - As at August 1978"
A N.Z. Road Transport Association costing schedule.(Unpublished)

"Motor Vehcile Licence form MR1, 1979-80"
Schedule of annual relicencing fees. N.Z. Post Office.

Personal communications with N.Z. Forest Products Limited and Carter Oji Kokusaku Pan Pacific Limited.

The following details the calculations summarised in Section 2:

(i) TRUCK CAPITAL COSTS

An average cost for a 3-axle log truck was obtained using RTA approach, and used as the basis for costing both 2 and 4-axle trucks.

Leyland Crusader	73,000	
Merc. 2632K	91,000	
Average	82,000	
Truck logging equipment	3,000	
Total	$85,000	for a 3-axle truck unit

Cost differences of 2, 3, and 4-axle twin-steer trucks,(namely E.R.F. and Leader) in the 216 kW (290 hp) size, were used to establish a comparative cost of 2, 3, and 4-axle twin-steer trucks.

The average difference between a 2 and a 3-axle truck was $10,000, and the average difference between a 3 and 4-axle truck (twin-steer) was $7,500.

The cost of a 4-axle truck with 3 axles in the rear set is the cost of a 3-axle truck plus $6,500.

Established truck capital costs are thus:

$75,000

$85,000

$92,500

$91,500

(ii) TRUCK RUNNING COSTS

Diesel and Oil -

Diesel at 19.7 cents/litre (July 1979)
Consumption rate 59.48 litres/100 km (assume all trucks same)

→	Diesel cost	11.7 cents/km
	Oil cost	0.4 cents/km
Total fuel and oil		12.1 cents/km

Annual cost at 80,000 km/yr = $9680

Tyres -

Using RTA cost per tyre at $260 for a 50,000 km tyre life

→ Cost/tyre/year (80,000 km) = $416

Annual costs for different trucks (incl. spare) are:

(7 tyres) $2912

(11 tyres) $4576

(13 tyres) $5408

(15 tyres) $6240

Repairs & Maintenance -

Based on August 1978 RTA repairs and maintenance cost rate for a 3-axle truck of 13.6 cents/km, add 10% inflation to July 1979, gives 15 cents/km. Estimate this repairs and maintenance cost is split as follows for a 3-axle truck:

Component	Engine	Transm.	Front axle	Mid axle	Rear Axle	Cab etc.	Total
R & M cost per km.	4 cents	2 cents	1 cent	2.5 cents	2.5 cents	3 cents	15 cents

For trucks with similar power,transmission and G.C.W., (assuming R & M on the extra steering axle the same as R & M on extra rear tag axle), the annual costs for 80,000 km/yr, are as follows:

(12.5 cents/km) $10,000

(15.0 cents/km) $12,000

(16.0 cents/km) $12,800

(16.0 cents/km) $12,800

Depreciation - (Running element) Based on RTA treatment of 2/3 of capital cost over 650,000 km
Using the established capital costs and 80,000 km/yr, gives the following annual costs:

(7.7 cents/km) $6160

(8.7 cents/km) $6960

(9.5 cents/km) $7600

(9.4 cents/km) $7520

Road User Charges - Using current rates effective April 1, 1979, and 75% of running on-highway (60,000 km/yr), gives the following annual costs:

(14 tonne → 6.7 cents/km) $4020

(15 tonne → 3.1 cents/km) $1860

(19 Tonne → 6.2 cents/km) $3720

(20 tonne → 7.3 cents/km) $4380

(22 tonne → 5.0 cents/km) $3000

(22 tonne → 5.0 cents/km) $3000

(iii) TRUCK STANDING COSTS

Depreciation - (Standing element) Based on RTA treatment of 1/3 of capital cost over 7 years, gives the following:

$3571

$4047

$4404

$4357

Driver wages - RTA cost for August 1978 was $15,669 per year
Add 5% to July 1979 gives $16,452

Registration - From current M.O.T. schedule of fees gives:

$52

$55

$59

$59

Insurance - Using RTA schedule on appropriate capital costs and $400 A.C.C. levy, gives:

(2299 + 400) $2699

(2599 + 400) $2999

(2824 + 400) $3224

(2794 + 400) $3194

Overheads - RTA August 1978 schedule gave $3896 per year on items ix & x - add 10% inflation to July 1979, gives $4285

Interest - Using RTA schedule as guide, base interest cost on:

0.3 x ave. capital at 10% gives 0.0150 x capital
0.7 x ave. capital at 15% gives 0.0525 x capital
plus ave. capital at 1.5% gives 0.0075 x capital
(ave. capital = ½ capital value)
Total 0.0750 x capital value gives:

$5625

$6375

$6937

$6862

(iv) TRUCK TARE WEIGHTS

An average tare weight for a 3-axle truck was obtained from LIRA weighbridge survey work, and used as a basis to estimate tares for 2 and 4-axle trucks. Ave. 3-axle truck (single bolster) tare = 9.2 tonnes.

Comparative 2, 3, and 4-axle truck kerb weight specifications for 216 kW size units (namely E.R.F. and Leader), gave a 1.4 tonne difference between 2 and 3

axles, and a 0.8 tonne difference between 3 and 4 (twin-steer) axles.

Tare weight of a 4-axle truck with 3 axles in the rear set is tare weight of a 3-axle truck plus 1.3 tonnes.

Established tare weights of truck units are thus:

7.8 tonne

9.2 tonne

10.0 tonne

10.5 tonne

(v) TRAILER CAPITAL COSTS

Average costs as obtained from LIRA surveys of trailer manufacturers, gave average capital costs of:

$7530

$10925

$11820

$11945

$15550

(vi) TRAILER RUNNING COSTS

Tyres - Based on RTA schedule and trailer tyre data obtained from NZFP and Pan Pacs, the following annual

costs were derived for this analysis:

(4 tyres, 80,000 km/yr, ½ unladen) $1250

(8 tyres, 40,000 km/yr, laden) $2000

(8 tyres, 40,000 km/yr, laden) $2000

(12 tyres, 40,000 km/yr, laden) $3000

Repairs & Maintenance - Trailer repairs and maintenance cost data supplied by Pan Pacs and NZFP, gave the following averaged annual costs for this exercise:

$776

$1785

$2255

$3000

Road User Charges - Using current rates effective April 1, 1979 and 75% of running (truck) being on-highway = 60,000 km/yr, and 2 and 3-axle trailers piggy-backed when empty, get:

(7 tonne → 60,000 km/yr) $1349

(8 tonne → 60,000 km/yr) $2176

(15 tonne → 30,000 km/yr) $1453

(16 tonne → 30,000 km/yr) $1827

(17 tonne → 30,000 km/yr) $2719

(20 tonne → 30,000 km/yr) $1653

Depreciation - For trailers depreciation is treated as standing cost only.

(vii) TRAILER STANDING COSTS

Depreciation - Based on trailer life of 10 years, with trailer capital cost being as listed but nil residual value. Average annual depreciation is:

 $753

 $1092

 $1182

 $1194

 $1555

Registration - From current M.O.T. schedule of fees:

1-axle dolly (semi-trailers)	$35
All others (full trailers)	$38

Insurance - Using RTA schedule:

On first $2000 value = $73
Add $2 for each extra $100 value, plus 50% area loading, gives the following:

 $274

 $376

 $403

 $406

 $514

Overheads - Assume the same for all trailers and included in truck unit standing costs.

Interest - Using RTA schedule as for truck units, gives:

$565

$819

$886

$896

$1166

(viii) TRAILER TARE WEIGHTS

Using average tare weights obtained from LIRA surveys, gives:

	(New Units)	(Units in Use)	Average
	(2.2 tonnes)	(2.0 tonnes)	2.1 tonnes
	(3.0 tonnes)	(3.0 tonnes)	3.0 tonnes
	(3.1 tonnes)	(3.3 tonnes)	3.2 tonnes
	(3.3 tonnes)	(3.8 tonnes)	3.5 tonnes
	(4.4 tonnes)	(5.2 tonnes)	4.8 tonnes

(ix) LOG CARTAGE COSTS (DOLLARS PER TONNE)

Use average payload haul distance of 40 km with trucks achieving 4 loads/day over 250 days/year, gives 80,000 km per year total and trucks carrying 1000 loads/year.

Therefore tonnes of logs hauled per year is payload x 1000

$$\text{Log cartage cost} = \frac{\text{Total operating cost/yr}}{\text{Payload} \times 1000}$$

CALCULATION DETAIL - SHORT-LOG CARTAGE LAYOUTS

A similar approach to that in Appendix I is used with the following added assumptions:

The truck purchase costs, truck operating costs, trailer running costs, gross weight limits, and achieved loads per year for short-log rigs, are assumed the same as for long-log rigs with equivalent axle layouts.

The main differences then, that have been accounted for are in trailer purchase costs, trailer standing costs, and trailer tare weights. These are detailed as follows:

(i) TRAILER CAPITAL COSTS

Average costs as obtained from LIRA surveys of trailer manufacturers, give average capital costs of:

$7530

$12485

$12485

$15945

(ii) TRAILER STANDING COSTS

Depreciation - Based on trailer life of 10 years, with trailer capital costs being as listed, and nil residual value. Average annual depreciation is:

$753

$1248

$1248

$1594

Registration - From current M.O.T. schedule of fees:

Semi-trailers	$35
All others (full trailers)	$38

Insurance - Using RTA schedule:

On first $2000 value = $73
Add $2 for each extra $100 value
plus 50% area loading, gives:

 $274

 $421

 $421

 $526

Overheads - Assume the same as for all trailers and included in truck unit standing costs.

Interest - Using RTA schedule as for truck units, gives:

 $565

 $936

 $936

 $1196

(iii) TRAILER TARE WEIGHTS

Using average tare weights obtained from LIRA surveys, gives:

 2.4 tonnes

 3.4 tonnes

 3.8 tonnes

 5.0 tonnes

CALCULATION DETAIL - "BAILEY BRIDGE" LAYOUTS

Many variations of "Bailey Bridge" semi-trailer layouts are in use, with the 3-axle Bailey Bridge trailer being a popular choice.

The comparative log cartage cost of this layout was derived using the same approach as in Appendices I and II.

The truck purchase costs, truck operating costs, trailer running costs (except for Road User Charges, due to not piggy-backing Bailey Bridge trailers), gross weight limits, and achieved loads per year for the Bailey Bridge layout is assumed the same as for the long-log and short-log rigs with equivalent axle layouts.

Calculation results for the Bailey Bridge layout, shown in Section 2.4, are:

Truck capital cost		$85,000
Trailer capital cost		$24,000
Truck standing costs		$34,213 p.a.
Truck running costs		37,596 p.a.
Trailer depreciation		2,400 p.a.
Trailer insurance & Registration		804 p.a.
Trailer interest		1,800 p.a.
Trailer repairs & maintenance		3,000 p.a.
Trailer Road User Charges		3,306 p.a.
Total rig operating cost per year		$86,119
Gross weight limits	Class I	39.0 tonnes
	Class II	36.5 tonnes
Truck unit tare weight		9.2 tonnes
Trailer unit tare weight		7.8 tonnes
Payloads	Class I	22.0 tonnes
	Class II	19.5 tonnes
Log cartage costs	Class I	$3.91 per tonne
	Class II	$4.42 per tonne