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# Log/chip B-train: a new concept in two-way hauling

**Abstract**

In Canada, raw forest products are generally transported by vehicles designed to handle either wood chips or logs, and therefore the vehicles carry a payload during only half of their operating hours. In western Canada, several forest operators have identified haul routes where a vehicle capable of hauling both chips and logs could be productive on both legs of a round trip. The Forest Engineering Research Institute of Canada (FERIC) co-ordinated the design and deployment of an 8-axle B-train vehicle having dual commodity capabilities, and monitored its operation during the first eight months of 2001. This report describes key features of the trailers and the operation, and presents an economic analysis.

**Keywords**

Road transportation, Logging trucks, B-train, Wood chips, Chip van, Multipurpose trailer, Dual commodity trailer.

**Author**

C.R. Webb,
formerly of FERIC,
Western Division

## Introduction

As described in earlier reports (Michaelsen 1996; Williams 1995; Jalinier 1993), the Forest Engineering Research Institute of Canada (FERIC) documented potential transportation cost savings of between 25 and 40%, using van-type semi-trailers designed to haul both logs and wood chips. In New Zealand, FERIC observed straight truck/full trailer configurations being used in similar two-way hauls.

Several FERIC members in British Columbia and Alberta have identified haul routes where a suitably-designed vehicle could carry logs in one direction and return with a load of wood chips, theoretically doubling the vehicle utilization rate. This should result in a significant reduction in the overall transportation costs. In western Canada, the eight-axle B-train configuration has emerged as the primary carrier of wood chips and, to a lesser extent, of cut-to-length logs. Therefore FERIC proposed that a modified chip-hauling B-train configuration be designed and a prototype unit placed in revenue service to demonstrate the concept and to evaluate the economics and operating characteristics of such a unit.

To evaluate the prototype, FERIC is working with Weldwood of Canada Limited's Hinton, Alberta Division and its wholly owned subsidiary, Sunpine Forest Products Ltd. From the harvesting operations of Weldwood's Hinton Division, peeler logs are sent to the Sunpine laminated veneer lumber plant at Strachan, Alberta, and sawlogs to the Sunpine sawmill at Sundre, Alberta. In return, wood chips from both mills are sent to the Weldwood pulp mill in Hinton. Trimac Transportation Services Inc. (Bulk Systems), is the primary contractor for hauling wood chips to the pulp mill and enthusiastically agreed to participate in the project. The trailers were designed and fabricated by K-Line Trailers Ltd. of Langley, B.C. in the fall of 2000 (Figure 1). The trailer set was purchased by Trimac and put into service January 19, 2001.

Figure 1. The log/ chip B-train.

## Objectives

The objectives of the project were to:

- Design and build a dual-commodity B-train trailer set patterned on the western Canadian style of chip-hauling B-train.
- Place the new B-train in revenue service and evaluate its performance from both functional and economic points of view.

## Methodology

FERIC researchers collaborated with representatives from Weldwood, Trimac and K-Line Trailers to define the design criteria for the trailers. The dropped belly, van-type B-train, designed for top loading and flow-through dumping, has become the predominant configuration for hauling wood chips in western Canada. Therefore this design became the starting point for designing the dual commodity vehicle.

To support the design process, FERIC gathered weights and dimensions of B-train log loads typical of the bundles that would be carried by the new trailers, and calculated block load densities for use by K-Line engineers.

When the trailers were delivered to Bulk Systems at Hinton, FERIC began monitoring the operation, gathering data on cycle times, gross and net weights hauled, and operational problems and solutions. Comparative data were also obtained for single commodity log and chip B-trains operating on the same routes.

## Design features

The lengths of the two trailer boxes were determined by the log lengths specified by the two Sunpine mills receiving the logs, with due consideration of the applicable provincial vehicle weight and dimension regulations. The design selected carries a single bundle of logs in a short front trailer, and two bundles in a longer rear trailer. It was decided at the outset, that the prototype would be restricted to yard-to-yard service, thereby avoiding the additional rigours of travelling on forest access roads until the design was proven.

In addition to the front and rear doors typical of a chip B-train, wide side doors, as observed in the New Zealand operation, were specified to facilitate the loading and unloading of logs and to avoid interior wall damage from the log grapple. The initial application utilizes butt-n-top loaders for loading and unloading, but future applications could make use of wheeled front end log loaders.

The log bunks and stakes were integrated into the structural design, with the stakes providing support for the walls and functioning as door posts for the side doors. Careful attention was paid to the choice of cross-sections for both bunks and stakes to minimize impediments to chip flow during unloading, while providing the necessary strength.

A new method of deploying the chip cover tarps had to be devised, as traditional designs were not compatible with the side doors.

## Operating experience

The current arrangement for log shipment starts with cut-to-length logs being brought

Forest Engineering Research Institute of Canada (FERIC)

**Eastern Division and Head Office**
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
(514) 694-1140
(514) 694-4351
admin@mtl.feric.ca

**Western Division**
2601 East Mall
Vancouver, BC, V6T 1Z4
(604) 228-1555
(604) 228-0999
admin@vcr.feric.ca



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from cutblocks north and south of Hinton and off-loaded in the yard adjacent to Bulk Systems' Hinton depot. There the logs are reloaded into the log/chip B-train trailers (Figure 2) and transported to the mills at either Strachan or Sundre. The loading and unloading of logs have been relatively trouble free, although more care and time are needed to get correct weight distribution and to avoid damaging the trailer walls. The tarps, gathered atop the front of each trailer, are also vulnerable to being snagged by a log if the loader operator is not conscious of their location.

After following the new unit on its initial round trip between Hinton and Strachan in January, FERIC researchers returned in June and August to gather data on several round trips to both Strachan and Sundre. At Strachan, the logyard roads are narrow and built from native soil, with little evidence of aggregate. As a result, after several days of intermittent rain, the road surface became rutted and very greasy. In some places the bellies of the loaded log/chip B-train dragged on the high center between ruts. Difficulty was also experienced negotiating some of the 90 degree corners without the rear trailer slipping off the inside of the corner. In several instances a loader was required to pull the trailer back onto the road as the tractor moved slowly forward. No similar problems were observed at the Sundre logyard.

The driver of the log/chip B-train was assigned the additional duty of cleaning the log debris from the trailers and stowing the stake spacers and moveable rear bunk before "scaling out" and loading chips. The time required to accomplish this task varied between 12 and 23 minutes in good summer weather conditions. This operation would likely take longer in sub-zero temperatures.

The loading of chips from the overhead hoppers should not take longer for the log/chip B-train than for a regular chip B-train, with the exception of one critical point; the length of the lead trailer box is very close to that of the hopper discharge, meaning that the vehicle must be accurately placed to avoid chip spillage. In one instance observed at Strachan, the time taken to actually load the trailers was only 0.5 minute longer than the following regular chip B-train.

Figure 2. Loading cut-to-length logs at the transfer yard.

Designing a tarping system that would not interfere with the side-opening doors was challenging. The original powered system of roll-up nets supported by swing arms has evolved to simple, manually-deployed nets guided by taut cables temporarily stretched along the tops of the trailer side walls. An intermediate design consisting of manually-deployed tarps with side flaps proved to be too stiff and heavy for the driver to manipulate in freezing temperatures. With the current system, the time required to deploy the tarps varied between 15 and 20 minutes, compared to an average of 16 minutes for regular chip B-trains.

In the first eight months of operation, the cycle element causing the greatest concern was chip unloading. More often than not, several lifts of the elevating trailer dumper were required to discharge all of the chips from the log/chip B-train. Between each attempt, the driver had to open a side door in each trailer, climb in, and loosen the packed chips with a pitch fork. Additional time may be spent waiting for the chip-receiving hopper to empty before an electrical interlock will allow the dumper to be elevated again. The regular chip B-trains usually emptied completely in one lift of the dumper.

It is acknowledged that the chips produced at Strachan from the waste veneer, being long and thin, tend to pack together more than the thicker, shorter chips produced by the sawmill. This characteristic of the veneer chips

is compounded in freezing weather because they have a higher moisture content due to the soaking process used in veneer peeling. In addition, the long veneer chips do not appear to tumble, even with the trailers tilted at the maximum angle of 58 degrees at the Hinton dumper; the shorter sawmill chips tumble freely and therefore are less likely to hang up in the trailers. Compared to the Hinton dumper, more modern dumpers elevate to an angle of 62 degrees and can be equipped with vibrators, both of which improve chip discharge. Some of the discharging problems in the new trailers can also be attributed to the impediments to chip flow caused by the log bunks and by several crevices that tend to catch and retain chips. In particular, in the rear trailer, chips tended to pack at the second log bunk from the front, and bridge the gap between the underside of the bunk and the upper front corner of the belly.

Table 1 compares average loading and unloading times for single commodity vehicles with those for the log/chip B-train.

The round trip from Bulk Systems' Hinton depot to Strachan and return is 769 km and takes from 9.5 to 10.5 h driving time. The equivalent trip to Sundre and return is 844 km and takes from 10.5 to 11.3 h. FERIC observed total yard times at Strachan that averaged 1.9 h, and at Sundre, 1.8 h. The time spent after scaling out at the pulp mill scale, returning the vehicle to the Bulk Systems depot, parking and preparing the unit for log loading, loading three bundles of logs, securing the logs, and closing up the trailers for travel was only observed in its entirety once; on this occasion, the process took 2.3 h of which 1.7 h was log loading time and 0.1 h was driving time. On another day, FERIC observed the loading only, which took only 0.5 h with a more experienced operator. The driver's total "on duty" time for the day is often in the range of 14 to 15 h, leaving little if any room for delays in the regulated limit of 15 h/day.

## Economic analysis

To compare the economic performance of the three types of vehicles under consideration, we have compared average payloads, cycle times, annual payload projections and vehicle ownership and operating costs. Table 2 presents the average payloads obtained from scale data. Sample sizes vary but all included loads were hauled after April 1, 2001 when the allowable gross combined weight (GCW) for the 8-axle B-train in Alberta was increased to 63 500 kg.

**Table 2. Average payloads for single and dual commodity B-trains**

| Vehicle configuration | Commodity hauled | |
|---|---|---|
| | Chips (kg) | Logs (kg) |
| Chip B-train | 40 046 | - |
| Log B-train | - | 40 365 |
| Log/chip B-train | 34 901 | 34 894 |

**Table 1. Time to load and unload at the millyard [a]**

| Vehicle configuration | Hauling chips | | Hauling logs | |
|---|---|---|---|---|
| | Load (h) | Unload (h) | Load (h) | Unload (h) |
| Chip B-train | 0.77 | 0.82 | - | - |
| Log B-train | - | - | Unknown[b] | 0.64 |
| Log/chip B-train | 0.76 | 1.54 | 1.76 | 1.08 |

[a] Yard times are measured from "Scale in" to "Scale out" and are averages for various sample sizes ranging from 6 to 795 loads except log loading time for the log/chip B-train. The latter is an estimate, based on two observations, consisting of time required to travel from the Weldwood scale to the Bulk Systems yard plus time for trailer preparation, log loading, load securement, and closing up the trailers for travel.

[b] The log loading and hauling times for the log B-trains have not been monitored at the time of writing this report. This aspect may be investigated at a later date.

The average cycle time for a typical B-train hauling chips from Strachan to Hinton was found to be 12.0 h and from Sundre to Hinton, 12.8 h (Table 3). Cycle times for log-hauling B-trains varied widely depending on the location of the cutblock so a figure of 10.0 h was taken as being representative for units hauling to Strachan and 10.5 h for those hauling to Sundre. For the log/chip B-train, a cycle time of 14.4 h was derived for the Strachan haul and 14.8 h for the Sundre haul. Using these data and the number of operating hours expected per year, an estimate of the annual payloads can be calculated.

Ownership and operating costs for the different vehicle configurations were developed using FERIC's standard costing model (Appendix I). The cost to transport raw fibre was then calculated (Table 4).

Although the yard times are greater and the average payloads are smaller for the log/chip B-train than for the single commodity B-trains, the combination B-train is loaded in both directions on the haul route and has the lowest haul cost/tonne of the three vehicle configurations studied. Fuel consumption of the log/chip B-train is greater than the chip B-train during a cycle because the combination unit travels loaded in both directions and the cycle time is longer. When averaged over the entire trip, the fuel consumed is similar (36 L/h) because the log/chip B-train spends more time in the yard.

The cost per tonne on the longer haul to Sundre is about 3% greater than on the Strachan haul, but compared on a cost per tonne-kilometer basis, the figure for the Sundre haul is about 6% lower than for the

**Table 3. Comparison of annual payload projections by vehicle configuration and commodity**

| Vehicle configuration | Operating hours/year (h) | Average cycle time (h) | Average payload/cycle | | Payload hauled/year | |
|---|---|---|---|---|---|---|
| | | | chips (t) | logs (t) | chips (t) | logs (t) |
| Strachan haul | | | | | | |
| Chip B-train | 4 900 | 12.0 | 40.05 | - | 16 354 | - |
| Log B-train | 1 800 | 10.0 | - | 40.37 | - | 7 267 |
| Log/chip B-train | 3 700 | 14.4 | 34.90 | 34.89 | 8 967 | 8 965 |
| Sundre haul | | | | | | |
| Chip B-train | 4 900 | 12.8 | 40.05 | - | 15 332 | - |
| Log B-train | 1 800 | 10.5 | - | 40.37 | - | 6 921 |
| Log/chip B-train | 3 700 | 14.8 | 34.90 | 34.89 | 8 725 | 8 724 |

**Table 4. Comparison of haul costs**

| Vehicle configuration | Haul cost | | Cost savings [a] | |
|---|---|---|---|---|
| | $/t | $/t–km | Hauling chips (%) | Hauling logs(%) |
| Strachan haul | | | | |
| Chip B-train | 22.39 | 0.029 | - | - |
| Log B-train | 25.73 | 0.033 | - | - |
| Log/chip B-train | 17.32 | 0.023 | 23 | 33 |
| Sundre haul | | | | |
| Chip B-train | 23.89 | 0.028 | - | - |
| Log B-train | 27.02 | 0.032 | - | - |
| Log/chip B-train | 17.80 | 0.021 | 25 | 34 |

[a] Comparing haul costs in $/tonne.

shorter haul to Strachan. However, the cost of transporting the logs from the cutblocks to the Bulk Systems yard in Hinton, and off-loading them, has not been considered. This cost component could be quite variable, depending on the location of the cutblocks relative to Hinton.

Weldwood and Bulk Systems personnel have discussed two alternative log hauling scenarios. One arrangement would establish a log transfer location at an intermediate point on the haul route. The log/chip B-train would run empty from Hinton to the new log transfer location but the length of the primary log haul would be reduced. The ultimate scenario would see the log/chip B-train go into the cutblocks to pick up logs, thereby eliminating the current double handling of the log load.

## Conclusions

The design and construction of a set of B-train trailers capable of transporting loads of either wood chips or cut-to-length logs, was accomplished. The structural design developed by K-Line Trailers Ltd. successfully married log bunks and stakes with the traditional dropped belly of chip-hauling B-trains, while incorporating side doors to facilitate log handling.

From an operational point of view, the chip unloading segment of the haul cycle was the most problematic. A few crevices, particularly in the bellies of the trailers, were identified as contributing to chip hang-ups when dumping. The log bunks also impeded chip flow, particularly the second log bunk from the front in the rear trailer. These design problems were most evident when hauling the veneer chips, which, by their nature, tend to pack more closely and are less inclined to tumble when dumping than the thicker, shorter chips produced by the sawmill. If the dumper had been equipped with a vibrator, and/or had the ability to tilt an additional 4 degrees, i.e., to 62 degrees, as is the case at some other mills, the number and/or severity of chip hang-ups may have been reduced. A more efficient dump would reduce yard times for the log/chip B-train.

The driver's regulated "on duty" time limit is 15 h/day. The Hinton to Sundre round trip haul of 844 km is calculated to consume 14-15 h, leaving a small margin of time available for delays. This travel distance is about the maximum that should be considered for a single shift, single driver operation.

On the economic side of the picture, the data collected to date confirm the expectation that a vehicle loaded in both directions on its haul will show an economic benefit over vehicles operating empty 50% of the time. Further analysis to determine the cost of bringing the logs to the intermediate transfer point, and double handling them there, may reduce the benefit reported. However, this factor may be reduced or eliminated if the transfer point was relocated or the log/chip B-train was taken directly to the cutblocks.

## Recommendations

Additional monitoring should be undertaken under winter conditions especially with respect to chip loading and discharge functions.

If a more comprehensive economic analysis is desired, consideration should be given to capturing the cost of transporting the logs from cutblocks to the Bulk Systems yard in Hinton, or to another intermediate load transfer location, and the cost of unloading them there.

Consideration should be given to providing good quality road surfaces in logyards with adequate allowance for off-tracking of B-train trailers on 90 degree corners.

The feasibility of developing a computer model to assist in evaluating the results of variable inputs affecting the economics of the dual commodity B-train operation should be investigated.

When developing the next generation of the trailer design, careful consideration should be given to closing off all crevices and pockets where chips could hang up and cause blockages to chip flow when dumping. The small loss of chip volume may be out weighed by the time saved with fewer lifts required on the dumper.

When evaluating the log/chip B-train travelling to the cutblocks to load logs, careful consideration should be given to the quality of roads, since the initial trailer design was for minimum road clearance suitable for on-highway operation. In addition, adequate turn-arounds would be needed since the trailers would not be uncoupled.

To reduce the driver's "on duty" hours, consideration might be given to having a second operator (perhaps the person assigned to load the vehicle with logs) relieve the driver when he arrives at the Weldwood scale with a load of chips. This arrangement could reduce the driver's on duty time by an hour or more, depending on the time spent at the chip dumper.

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# Appendix I

## Ownership and operating cost ($/scheduled machine hour (SMH)) [a]

| | 8 axle Log/Chip B-train | | 8 axle Log B-train | | 8 axle Chip B-train | |
|---|---|---|---|---|---|---|
| | Tractor | Trailers | Tractor | Trailers | Tractor | Trailers |
| OWNERSHIP COSTS | | | | | | |
| Total purchase price (P) $ | 105 000 | 195 000 | 150 000 | 80 000 | 105 000 | 140 000 |
| Expected life (Y) y | 4 | 10 | 5 | 10 | 4 | 10 |
| Expected life (H) h | 14 800 | 37 000 | 9 000 | 18 000 | 19 600 | 49 000 |
| Scheduled hours/year (h)=(H/Y) h | 3 700 | 3 700 | 1 800 | 1 800 | 4 900 | 4 900 |
| Salvage value as % of P (s) % | 16 | 2 | 15 | 10 | 16 | 2 |
| Interest rate (Int) % | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| Insurance (Ins) $/y | 4 200 | 7 800 | 5 400 | 3 000 | 4 200 | 5 600 |
| License and registration (Lr) $/y | 2 625 | 40 | 3 375 | 40 | 2 625 | 40 |
| Salvage value (S)=((P•s/100) $ | 16 800 | 3 900 | 22 500 | 8 000 | 16 800 | 2 800 |
| Average investment (AVI)=((P+S)/2) $ | 60 900 | 99 450 | 86 250 | 44 000 | 60 900 | 71 400 |
| Loss in resale value ((P-S)/H) $/h | 5.96 | 5.16 | 14.17 | 4.00 | 4.50 | 2.80 |
| Interest ((Int•AVI)/h) $/h | 1.40 | 2.28 | 4.07 | 2.08 | 1.06 | 1.24 |
| Insurance (Ins/h) $/h | 1.14 | 2.11 | 3.00 | 1.67 | 0.86 | 1.14 |
| License and registration (Lr/h) $/h | 0.71 | 0.01 | 1.88 | 0.02 | 0.54 | 0.01 |
| Total ownership costs (OW) $/h | 9.20 | 9.57 | 23.11 | 7.77 | 6.95 | 5.19 |
| OPERATING COSTS | | | | | | |
| Fuel consumption (F) L/h | 36.0 | - | 40.0 | - | 36.0 | - |
| Fuel (fc) $/L | 0.59 | - | 0.60 | - | 0.59 | - |
| Lube & oil as % of fuel (fp) % | 15 | - | 15 | - | 15 | - |
| Annual tire consumption (t) no. | 10 | 20 | 5 | 10 | 13 | 27 |
| Tire replacement (tc) $/y | 3 900 | 7 800 | 2 100 | 4 200 | 5 070 | 10 530 |
| Annual operating supplies (Oc) $ | 1 800 | 1 450 | 1 000 | 800 | 1 800 | 1 450 |
| Annual repair & maintenance (Rp) $ | 25 100 | 10 800 | 20 000 | 5 000 | 25 100 | 10 800 |
| Shift length (sl) h | 14.0 | 14.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| Wages $/h (w) | 20 | - | 20 | - | 20 | - |
| Wage benefit loading (WBL) % | 35 | - | 35 | - | 35 | - |
| Fuel (F•fc) $/h | 21.24 | - | 24.00 | - | 21.24 | - |
| Lube & oil ((fp/100)•(F•fc)) $/h | 3.19 | - | 3.60 | - | 3.19 | - |
| Tires ((t•tc)/h) $/h | 1.05 | 2.11 | 1.17 | 2.33 | 1.03 | 2.15 |
| Operating supplies (Oc/h) $/h | 0.49 | 0.39 | 0.56 | 0.44 | 0.37 | 0.30 |
| Repair & maintenance (Rp/h) $/h | 6.78 | 2.92 | 11.11 | 2.78 | 5.12 | 2.20 |
| Wages & benefits (W•(1+WBL/100)) $/h | 27.00 | - | 27.00 | - | 27.00 | - |
| Total operating costs (OP) $/h | 59.75 | 5.42 | 67.43 | 5.56 | 57.95 | 4.35 |
| TOTAL OWNERSHIP AND OPERATING COSTS (OW+OP) $/SMH | 68.95 | 14.99 | 90.55 | 13.32 | 64.90 | 9.84 |
| COMBINED TRACTOR AND TRAILER OWNERSHIP AND OPERATING COSTS $/SMH | 83.94 | | 103.87 | | 74.74 | |

[a] These costs are estimated using FERIC's standard costing methodology for determining machine ownership and operating costs for new machines. The costs shown here do not include supervision, profit and overhead, and are not the actual costs for the contractor or the company studied.