FASTTRUCK - A TRUCK SCHEDULING SYSTEM TO IMPROVE THE TRANSPORT EFFICIENCY OF IN-FIELD CHIPPING OPERATIONS

Mauricio Acuna*, Mohammad Ghaffariyan
CRC Forestry
University of Tasmania, Hobart, Australia,
*Private Bag 12, Hobart, TAS, 7001, Australia
Email: Mauricio.Acuna@utas.edu.au

ABSTRACT

An important problem in forest operations is the daily transport of logs or chips from different coupes being harvested, with known supplies, to destinations with their daily demands. The basic objective is to satisfy the demand for different products at each destination and maximize the utilisation of the harvesting equipment at each origin, while minimising transportation costs and waiting times within technical, policy and labour constraints.

This paper presents the results of a trial of FastTRUCK, a truck scheduling system developed by the CRC for Forestry, to evaluate some of the factors that affect transport efficiency of Australian in-field chipping operations. The analysis focused on the effect of chipper productivity and utilisation, number of chipping operations accessible to each truck, truck loading and unloading time, net payload on daily transportation costs, number of trucks, and average truck utilisation.

According to the results obtained payload and chipper utilisation are the major factors affecting transport costs. Potential savings of 52% and 29%, respectively, are possible to obtain with a better control and management of these factors.

Keywords: In-field wood chipping, simulated annealing, wood supply chain, transport efficiency

INTRODUCTION

Log transport by trucks constitutes a major part of the operational costs. It is therefore important to organise log and chip transport efficiently as trucks are expensive and operational costs are high. Many forestry transport managers are aware that their fleets could be better organised, perhaps with computer aided dispatching, routing and scheduling systems.

The main goal of routing and scheduling systems is to minimise transportation costs and waiting times within technical, policy and labour constraints. Vehicle routing problems (VRP) are difficult to solve and are unfit for timber transport vehicle routing problems (TTRVP) because the latter has many important features (Karanta et al. 2000). The closest problem class to TTRVP in the vehicle routing literature is freight pickup and delivery problems with time windows (Dumas et al. 1991). These problems shared many features but there are other elements that make
TTRVP a unique problem; for example, the pickup sites vary from day to day, there are strict time intervals to when a truck can enter an unloading (delivery) site, there are several type of timber and a given mill needs a specific type of timber, not all the truck can serve all pickup or delivery nodes, etc.

In-field wood chipping operations are common in Blue Gum (Eucalyptus globulus) plantation harvests across Australia. The harvesting systems typically consists of one feller buncher, one or two grapple skidders, and a delimer-debarker-chipper (DDC) (Figure 1). The system produces woodchips at the roadside in the forest and are particularly sensitive to planning and logistics because the DDC is not able to work unless a truck is on site to be loaded. The use of truck scheduling systems are valuable tools to evaluate the required level of receiving capacity at the woodchip terminal; very significant capital expenditure can be avoided based on the assessment of the required number of hydraulic dumpers (loading platforms) (Figure 1).

![Figure 1: In-field chipping operation and woodchip terminal at port](image)

The objective of this study was to evaluate some of the factors that affect transport efficiency of Australian in-field chipping operations. The analysis focused on the effect of chipper utilisation, number of chipping operations accessible to each truck, truck unloading time, and net payload on daily transportation costs, daily production, number of trucks, and average truck utilisation.

**MATERIALS AND METHODS**

**FastTRUCK scheduling system**

FastTRUCK is a windows-based system developed in Visual C++. It uses input from the existing parameters of the transport component of an operation and generates a range of alternatives to determine the optimal (or near optimal) operating scenario (Acuna 2011). The aim of the system is to minimise total transportation costs, and considers travel loaded and unloaded time, stood
down time and fixed costs. To determine optimal schedules, FastTRUCK requires different input parameters (Table 1).

**Table 1: Inputs required by FastTRUCK**

<table>
<thead>
<tr>
<th>Trucks</th>
<th>Dumpers</th>
<th>Chippers</th>
<th>Routing options</th>
</tr>
</thead>
</table>
| 1. Min and Max time per shift  
2. Speed empty and loaded  
3. Truck payload  
4. Cost travel loaded and unloaded  
5. Cost stood down and fixed cost | 1. Number of dumpers available  
2. Starting and ending working time  
3. Capacity (trucks/hr) | 1. Number of chippers available  
2. Starting and ending working time  
3. Loading time  
4. Productive time out of scheduled time | 1. Multiple destinations by truck  
2. One destination by truck  
3. Two or three destinations by truck (clusters) |

As output, FastTRUCK reports the optimal number of trucks required for the operation, total transportation cost, total volume of chips hauled to dumpers, average truck utilisation, average truck waiting time and average loaded running percentage (travel loaded /total travel distance). Detailed results by truck are exported to Microsoft Excel® and include total time, total cost, trips to dumpers, waiting time, utilisation, running loaded percentage, arrival times at forests and dumpers, and optimal schedule for one day.

**Simulated annealing algorithm**

Optimal truck schedules are created by FastTRUCK using a simulator and a simulated annealing algorithm. The simulator produces truck schedules and allow the system to calculate metrics such as total time, waiting time and total cost. Simulated annealing is a meta-heuristic whose approach is similar to the random descent method in that the neighbourhood is sampled at random. It differs in that it is possible to escape from being trapped at a local optimum by accepting worse solutions, with a small probability, during its search iterations (Reeves 1993).

**Parameters for analysis**

In the case scenario, the following parameters were used for the analysis:

- **Trucks:**
  - 82.5 t GVM road trains (50 t payload)
  - Truck working shift limit: 6 h minimum to 12 h maximum
  - Average road speed 75 km/h empty and 65 km/h loaded
  - Annual freight task of 900,000 tonnes
  - Centrally dispatched fleet (any truck can go to any chipper)
  - Average haulage distance of 72 km with lower and upper lead distance of 29 and 150 km respectively
- **Infield chippers:**
  - 8 active harvest operations on single 10 h shift
  - Loading time 60 min per truck
  - Chipper utilisation 90%
- **Receiving facility:**
  - One facility with two dumpers
  - Capacity per dumper of 250 gross metric tonnes per hour (unload up to 5 trucks per hour)
  - Facility open 14 h per day

A sensitivity analysis was conducted to determine the impact of chipper productivity and utilisation, number of chipping operations accessible to each truck (routing option), truck loading and unloading time, and net payload on four performance metrics: 1. Fleet size, 2. Daily production (tonnes), 3. Average truck utilisation (%), and 4. Transportation cost ($/tonne). In addition, total cost savings for an annual freight task of 900,00 tonnes were calculated by operational factor.

**RESULTS AND DISCUSSION**

**Impact of reduced chipper utilisation**

Table 2 shows the effect of reduced chipper utilisation. In each case the chipper was scheduled for 10 hours. There is a significant increase in the number of trucks (29%) when the chipper utilisation is increased from 75% to 90%. This is a consequence of the productive working times associated, which are 450 min (7 truck arrivals), 510 min (8 truck arrivals), and 540 min (9 truck arrivals), for a chipper utilisation of 75%, 85%, and 90%, respectively. The increased number of arrivals with 90% chipper utilisation has a substantial impact on the number of trucks required for the operation, which in turn increases the transport cost per tonne. However, savings of around $1/tonne are expected for the chipper when its utilisation increases from 75% to 90%.
Table 2: Effect of chipper utilisation

<table>
<thead>
<tr>
<th>Performance metrics</th>
<th>Chipper utilisation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75%</td>
</tr>
<tr>
<td>Fleet size (number of trucks)</td>
<td>20</td>
</tr>
<tr>
<td>Unit cost ($/tonne)</td>
<td>9.49</td>
</tr>
<tr>
<td>Daily production (tonnes)</td>
<td>2,800</td>
</tr>
<tr>
<td>Average truck utilisation (%)</td>
<td>88.3</td>
</tr>
</tbody>
</table>

*Control scenario

Impact of increased dispatching restrictions

Table 3 shows the effect of restricting the number of in-field chipping operations an individual truck can service. There is a 7% reduction in the number of trucks required for the operation when multiple chipping operations are available to service. Given that the two dumpers are in the same geographical location, the running loaded percentage is always 50% and there is no possibilities for backhauling. Thus, the transport cost reduction attributed to multiple destinations is only 3%.

Table 3: Effect of the number of operations available to service by each truck

<table>
<thead>
<tr>
<th>Performance metrics</th>
<th>Number of in-field chipping operations available to service</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Fleet size (number of trucks)</td>
<td>30</td>
</tr>
<tr>
<td>Unit cost ($/tonne)</td>
<td>10.16</td>
</tr>
<tr>
<td>Daily production (tonnes)</td>
<td>3,600</td>
</tr>
<tr>
<td>Average truck utilisation (%)</td>
<td>87.9</td>
</tr>
</tbody>
</table>

* Control scenario

Impact of increased loading times

Table 4 shows the effect of loading time. Increasing the loading time from 50 min/truck to 60 min/truck results in an increased cost of $0.39. A further rise in loading time from 60 min/truck to 70 min/truck results in a reduced cost per tonne (compared to 60 min loading time) due to the substantial reduction in the fleet size. Loading time has also a direct effect on the number of daily truck arrivals (10 with 50 min/truck, 9 with 60 min/truck, and 7 with 70 min/truck) and number of trucks required for the operation. Consequently, the daily production is reduced by 30% when loading time increases from 50 min/truck to 70 min/truck.
Table 4: Effect of loading time

<table>
<thead>
<tr>
<th>Performance metrics</th>
<th>Loading time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 min/truck</td>
</tr>
<tr>
<td>Fleet size (number of trucks)</td>
<td>29</td>
</tr>
<tr>
<td>Unit cost ($/tonne)</td>
<td>9.54</td>
</tr>
<tr>
<td>Daily production (tonnes)</td>
<td>4,000</td>
</tr>
<tr>
<td>Average truck utilisation (%)</td>
<td>87.7</td>
</tr>
</tbody>
</table>

* Control scenario

Impact of payload

Table 5 shows the effect of net payload. Assuming the same loading time, there is no major effect on fleet size when net payload increases from 47 to 53 tonnes/truck. If that is not the case, the advantages of hauling bigger payloads might be offset by the extra time required to load the trucks. Increasing payload from 47 to 53 tonnes has the biggest single impact on transport cost per tonne (more than $1.1/tonne) and daily production (432 tonnes).

Table 5: Effect of net payload

<table>
<thead>
<tr>
<th>Performance metrics</th>
<th>Net payload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47 tonnes/truck</td>
</tr>
<tr>
<td>Fleet size (number of trucks)</td>
<td>28</td>
</tr>
<tr>
<td>Unit cost ($/tonne)</td>
<td>10.53</td>
</tr>
<tr>
<td>Daily production (tonnes)</td>
<td>3,384</td>
</tr>
<tr>
<td>Average truck utilisation (%)</td>
<td>86.4</td>
</tr>
</tbody>
</table>

* Control scenario

Annual cost savings

Figure 2 shows the annual savings for an annual freight task of 900,000 tonnes which corresponds to the volume hauled by one of the forest companies in Western Australia. The total savings resulting from a better control of the operational factor assessed in this study are in excess of 2 million dollars. More than 50% of these savings are explained by an increase in payload. Increasing the payload from 47 tonnes to 53 tonnes results in a reduction in transport costs of $1.2 per tonne or $1,080,000 per year for an annual volume of 900,000 t. These results are consistent with those obtained in previous studies carried out by the CRC for Forestry (Brown 2008). The second major operational factor is chipper utilisation. Increasing chipper utilisation from 75% to 90% represents a slight increase in transport cost of 4%, but also results in a drop in the chipping cost through improved chipper utilisation. Through increased chipper utilisation it is estimated that an overall saving of approximately $600 000 can be made annually for the operation presented in the example.
CONCLUSIONS

- The impact of operational factors on transport costs and opportunities for improvements can be determined by using optimal scheduling systems such as FastTRUCK.

- Large savings in transport costs are possible without a major shift in technology by optimising truck schedules, maximising payload and improving the efficiency of chipping operations.

- Payload and chipper utilisation are the major factors affecting transport costs. Control and improvement of these factors accounted for 52% and 29% (respectively) of the potential savings obtained.

Figure 2: Annual savings for a freight task of 900 000 tonnes
LITERATURE CITED


