Proceedings of the 2021 Winter Simulation Conference
S. Kim, B. Feng, K. Smith, S. Masoud, Z. Zheng, C. Szabo and M. Loper, eds.

SIMULATING TRUCK FLEET CONFIGURATION FOR WOOD TERMINALS

Christoph Kogler
Alexander Stenitzer
Peter Rauch

Institute of Production and Logistics
University of Natural Resources and Life Sciences, Vienna
Feistmantelstrasse 4
Vienna, 1180, AUSTRIA

ABSTRACT

The alarming bottleneck of self-loading truck capacity after forest calamities challenges resilient wood transport in leading countries of the wood-based industry. Consequently, a discrete event simulation model of a multi echelon unimodal wood supply chain, spanning from self-loading truck pickup at forest landings to wood transshipment at terminals and final semitrailer truck transport to industry, was developed to provide optimal truck fleet configurations for different terminal configurations. Varying transport distance, terminal utilization and truck payload scenarios provide valuable decision support to develop contingency planning strategies for various regions. Optimal results regarding the number of self-loading trucks, prime mover trucks and semitrailers deduced by full enumeration outperformed unimodal transport cost benchmarks for short, medium and long distances by 5.45%, 6.95% and 11.28%, respectively. In order to better manage increasingly frequent natural disturbances, future research should extent simulation models to include intermediate storage in wood stockyards and to consider wood value loss.

1 INTRODUCTION

Wood supply chains suffer from risks and natural disturbances. In order to cope with increasingly frequent and larger quantities of salvage wood after forest calamities, immediate wood transport is needed to avoid further wood value loss and to prevent secondary damages such as bark beetle infestations. Empirical studies (Malinen et al. 2014) report an alarming shortage of log transport capacity mainly due to a lack of self-loading truck drivers. This bottleneck will become even more acute in the future, due to an upcoming wave of retiring drivers and the difficulty to attract young drivers because of harsh working conditions in mountainous regions, where they have to navigate on steep and narrow forests roads (Borchert et al. 2019).

Recent scientific literature reviewed (Kogler and Rauch 2018) and investigated multimodal wood supply chains (Kogler and Rauch 2019; Kogler and Rauch 2020a; Kogler and Rauch 2020b). Multimodal wood supply chains, where wood is transshipped from trucks to train wagons, have the advantage that trucking resources are efficiently used for short distance transport between forests and train terminals mitigating the self-loading truck driver bottleneck. Nevertheless, in many cases train transport is costly for short distances, the availability of train wagons is restricted in many regions and rail carriers are less reliable in providing empty wagons and picking up full loaded wagons than unimodal truck transport.

Therefore, another opportunity to mitigate the self-loading truck capacity bottleneck is to introduce semitrailer truck transport in a multi echelon unimodal wood supply chain. First research approaches indicate great potential of high-capacity truck transport in Finnish case studies (Korpinen et al. 2017; Väätäinen et al. 2020) as well as wood transshipment terminals for semitrailer trucks in Austria (Kogler et al. 2020; Kogler et al. 2021), but a research gap exists regarding the optimal truck fleet configuration for different terminal configurations in multi echelon unimodal wood supply chains.

2 DISCRETE EVENT SIMULATION MODEL

The developed discrete event simulation model includes modules for forestry, terminal and industry to simulate loading, transporting, coupling, uncoupling, queuing, transshipping and unloading processes of self-loading trucks, semitrailers and prime mover trucks. The wood flow of parameterizable simulation experiments (e.g., process times, operating costs, number of transshipment lots, truck payloads) can be observed in animation and process logic views. The statistic view shows important key performance indicators during runtime such as delivered volume and costs in total and per week, queuing, working and transport times as well as utilizations of self-loading trucks, semitrailers and prime mover trucks.

3 RESULTS AND DISCUSSION

Optimal truck fleet configurations regarding cost per ton and turnover per week in tons were attained by simulation runs on the basis of a full enumeration and compared to well performing heuristic solutions. Practical results were condensed in transport planning tables for terminals with 2, 4, 6 and 8 transshipment lots and the most relevant transport distance, terminal utilization and truck payload configurations representing a majority of transport planning options to provide transport managers a useful decision support tool. Depending on different scenario settings optimal truck fleet configuration involves 3–51 self-loading trucks, 8–70 semitrailers and 7–65 prime mover trucks. For optimal truck fleet configurations the relevant key performance indicators cost per ton, turnover in tons per week, saved working time per week in minutes and saved number of self-loading trucks vary between 21.25–35.70 € per ton, 1530–12,530 tons per week, 15,110–126,190 minutes per week and 4–40 self-loading trucks, respectively. Results show significant cost savings with increasing terminal size for the same turnover, because of shorter waiting times and increasing flexibility at the terminal. Moreover, results confirm that in a multi echelon unimodal wood supply chain less self-loading trucks are needed compared to a unimodal wood supply chain, because of shorter transport times. Higher truck payloads increase this effect and reduce transport times, queuing times, costs as well as the number of self-loading trucks employed and consequently provide an additional strategic option to mitigate truck driver bottlenecks after natural disturbances. Future research should include wood stockyards and consider wood value loss in simulation models enabling managing natural disturbances and prevent expensive, inefficient and unsustainable break downs of wood supply chains.

REFERENCES

Borchert, H., S. Gößwein, and M. Schusser. 2019. "How to Deal with an Upcoming Shortage of Wood Transporting Capacity in Germany". In *Proceedings of the 52nd International Symposium on Forestry Mechanization*, edited by I. Czupy, 151–160. Sopron, Hungary: University of Sopron Press.

Kogler, C., and P. Rauch. 2018. "Discrete Event Simulation of Multimodal and Unimodal Transportation in the Wood Supply Chain: A Literature Review". *Silva Fennica* 52(4):1–29.

Kogler, C., and P. Rauch. 2019. "A Discrete Event Simulation Model to Test Multimodal Strategies for a Greener and more Resilient Wood Supply". *Canadian Journal of Forest Research* 49:1298–1310.

Kogler, C., and P. Rauch. 2020a. "Contingency Plans for the Wood Supply Chain based on Bottleneck and Queuing Time Analyses of a Discrete Event Simulation". *Forests* 11(4):1–23.

Kogler, C., and P. Rauch. 2020b. "Game-Based Workshops for the Wood Supply Chain to Facilitate Knowledge Transfer". *International Journal of Simulation Modelling* 19(3):446–457.

Kogler, C., A. Stenitzer, and P. Rauch. 2020. "Simulating Combined Self-loading Truck and Semitrailer Truck Transport in the Wood Supply Chain". *Forests* 11(12):1–15.

Kogler, C., S. Schimpfhuber, C. Eichberger, and P. Rauch. 2021. "Benchmarking Procurement Cost Saving Strategies for Wood Supply Chains". *Forests* 12(8):1–18.

Korpinen, O. J., M. Aalto, P. Venäläinen, and T. Ranta. 2017. "Impacts of a High-Capacity Truck Transportation System on the Economy and Traffic Intensity of Pulpwood Supply in Southeast Finland". *Croatian Journal of Forest Engineering* 40:89–105.

Malinen, J., J. Nousiainen, K. Palojärvi, and T. Palander. 2014. "Prospects and Challenges of Timber Trucking in a Changing Operational Environment in Finland". *Croatian Journal of Forest Engineering* 35:91–100.

Väätäinen, K., J. Laitila, A. Perttu, A. Kilpeläinen, and A. Asikainen. 2020. "The Influence of Gross Vehicle Weight (GVW) and Transport Distance on Timber Trucking Performance Indicators – Discrete Event Simulation Case Study in Central Finland". *International Journal of Forest Engineering* 31(2):156–170.