Log Yards and Sort Yards of the Future: Development and Evaluation of a Simulation Model

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Vincent Monbourquette, Researcher, Modeling and Decision Support
Fattane Nadimi, Researcher, Modeling and Decision Support
Catalin Ristea, Research Leader, Modeling and Decision Support

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Log and Sort yards of the Future - Simulation Model Development and Evaluation – Technical Report no. 43

ABSTRACT

FPInnovations has developed a simulation based decision support tool to help log and sort yard managers quickly evaluate and quantify the impact of changes in the yard operation in a virtual framework. Some examples of changes that could be evaluated by the model include changes in the infrastructure, yard layout, machine combination, and yard throughput. The tool was tested and validated in a coastal log and sort yard, and is customizable to log and sort yards with similar operation. In this report, the model, its capabilities, and results from the test site are presented.

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REVIEWER

Denis Cormier, Research Manager,
Supply Chain Analytics, FPInnovations.

CONTACT

Denis Cormier, Research Manager,
Supply Chain Analytics, FPInnovations
514-782-4539
Denis.Cormier@fpinnovations.ca

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Executive Summary

FPInnovations developed a decision-support tool, based on discrete-event simulation, to help log yard and sort yard managers evaluate the impact of a variety of potential changes in their yards. There are two versions of the simulation model: one replicating the current operations of a Coastal British Columbia log-sorting yard that includes manual scaling and sorting, and the other considering a potential future automated scanner scaling station. This model was designed for evaluating the feasibility of potential infrastructure projects, including the installation of a scanning station, but also other alternative yard layout options intended to improve British Columbia Coastal log yard operations and increase machine efficiency. The model has been tested and validated with real-life data from one industrial collaborator.

In this study the log yard simulation model was used to evaluate a number of what-if operational scenarios and to analyze the effects of potential changes to log yard operations. The results indicate that an automated scanner station can contribute to savings of 16 to 23% in operating costs. However, the evaluation did not consider the infrastructure cost.

The key scenarios that can be analyzed by using the log yard simulation model include:

1. Evaluate the impacts of modifying the yard layout on the machinery key performance indicators (KPI) and yard throughput. Scenarios may include changing the location of the truck unload station, changing the location of the log sorting cells, having two sorting areas at two different places in the yard, exploring alternative locations for the debarking station, and changing the location and product allocation for storage areas.
2. Evaluate the effects of changing the log-arrival rate on machine utilization, machine travel distances, and machine travel time. Alternatives to consider may include changing the truck arrival rate, the bundle retrieval rate from water, and the load combinations on the trucks or in the log bundles.
3. Analyze the outcome of changing road conditions on total machine time per cubic metre of log flow within the log yard. In this case, capital investment in all or some roads within the yard can be analyzed to decide if the trade-off between road upgrade cost and machinery travel time in the yard would justify the investment or not.
4. Explore different throughput scenarios to evaluate the possibility of increasing the log volume through the facility. In this scenario, both log arrival rate and log-exit rate can be altered to analyze whether or not the log yard can handle changes in the product flow or to identify potential bottlenecks that might occur if yard throughput is changed.

Keywords: Log yard, sort yard, decision support, discrete-event simulation, scanner scaling, Coastal British Columbia forest operations

Introduction

In British Columbia, there is a growing concern amongst forest industry employers about the severe shortage of educated and skilled labour, including log scalers and graders. Attracting and developing qualified log scalers and graders to the industry remains a challenge, and much of the existing workforce is older and nearing retirement (Coastal Forest Industry Strategy Working Group, 2014). At the same time, recent advances in log-scanning technology, as well as the recent approval by Measurement Canada of an automated log-scaling system, offer the forest industry new opportunities to automate log-scaling operations and reduce scaling costs.

In 2014, the total volume of trees harvested in Canada was more than 153 million m^3 (Natural Resources Canada, 2016). Most logs have to go through a sort yard or a log yard before being delivered to the customer or to a sawmill.

Log yards and log sort yards are an important part of the forest products supply chain. Gradual changes in wood supply and in the wood products market, and pressure to lower production costs, have led to the need to increase the efficiency of log supply, and the need to recover more value from available resources. In this context, improved log yard and sort yard operation can reduce log-supply cost and enhance the efficiency of the log-value chain.

Log yards can impact the productivity of upstream harvesting and downstream log processes (Figure 1). Inefficiencies can make a log yard a bottleneck, which has negative impacts on the log-supply chain processes, and is associated with large costs such as penalties and customer loss. Consequently, log yard managers attempt to optimize the operation of multiple sequential processes with the goal of maximizing efficiency, throughput, and profitability.

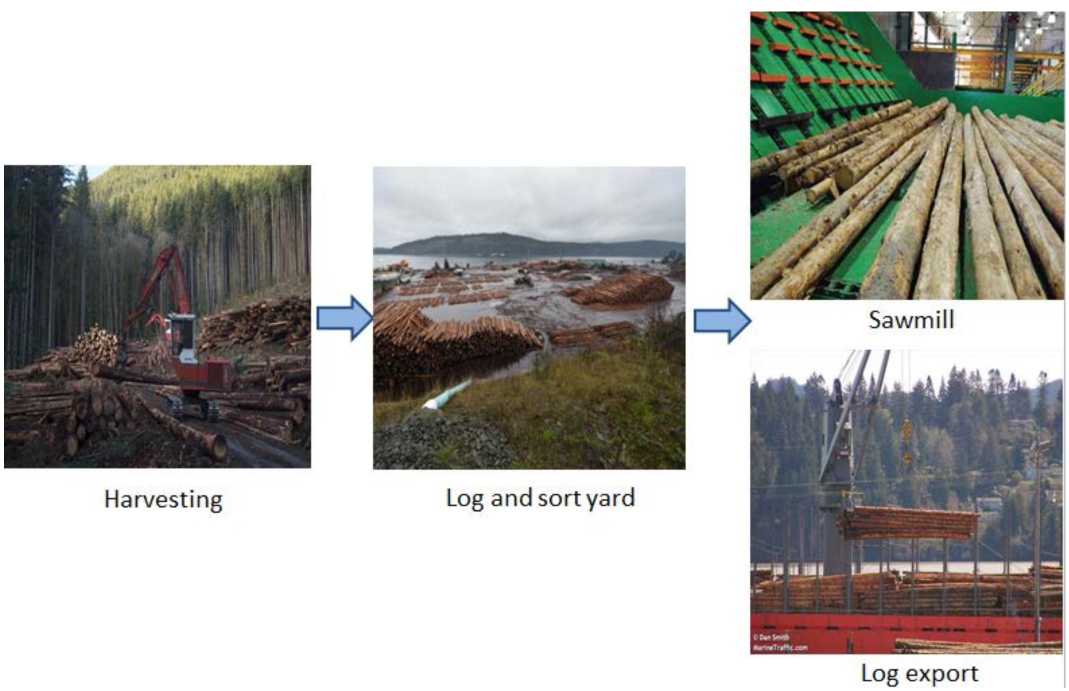

Figure 1. The relationship of the log yard or sort yard to upstream and downstream operations.

Many factors contribute to the efficient management of log yards and sort yards, and the managers must make many challenging decisions on a daily basis. First, they have to decide about the log volume from different sources (e.g., different suppliers and contractors, via land and/or water), log delivery rate, and load type. They need to order the right combination of loads to be able to fulfill customer/mill demand in a timely manner. Second, they need to optimize each process in order to maximize product flow through the site. This is achieved by making informed decisions regarding the number of machines, graders, and sorting cells, and regarding the placement of infrastructure components. Third, log yard managers need to manage log handling and processes in the yard, including sorting, storage, reclaim, debarking, staging, and shipment to the customer or supplying sawmills.

Traditionally, log yard managers have relied on experience and a trial-and-error process to optimize these variables. While experience-based and real-time decision-making is necessary for day-to-day and dynamic operations within a log yard, such an approach is not ideal for making tactical decisions and will not lead to continuous improvement. It is difficult to evaluate the impacts of modifying the yard layout, e.g., changing the location of the sorting cells or the debarker, without the help of a decision-support tool. Similarly, using trial-and-error to evaluate changes in truck and bundle load types is difficult, because such changes affect upstream harvest operations.

1 Objectives and Approach

The main objective of this project was to develop a decision-support tool to help log yard and sort yard managers evaluate the impacts of potential changes in the yard, and identify promising modifications. In this regard, there are two types of changes to consider:

> (1) Emulate the operations of an existing log yard or sort yard, and explore what-if questions related to the improvement of logistics and yard operations, such as yard layout, number of machines, machine types, etc.; and
>
> (2) Explore a next generation of log yards, i.e., those that incorporate recently developed and approved technologies, such as using scanner scaling instead of manual scaling.

FPInnovations' approach to this project included:

- Developing a coastal log yard/sort yard simulation model.
- Using the simulation system to evaluate the impacts of different types of layouts and to analyze the potential increases in efficiency and cost reductions associated with using new operations and logistics.
- Modifying the simulation model to consider the addition of scanner scaling, i.e., in place of using manual scaling.
- Analyzing scenarios that include new operations and layout which incorporate the use of scanner scaling at the log yard.

In fulfillment of the objectives, FPInnovations developed a simulation based decision support tool that aims to support log yard and sort yard managers in objectively analyzing "what-if" scenarios and in quickly quantifying the impacts of changes in the yard. The tool was developed based on operations at an individual site, but is adaptable to other, similar operations (the model is customizable, and for similar operations it can be adapted for a new site, by defining the new site's characteristics in an Excel file). For more details please see Section 3.3.

This report describes the development of the simulation-based tool and its features, and discusses the case study in which the log yard simulation decision-support tool was applied.

2 Model Development

To achieve the objectives described above, a simulation model was developed in the generic SIMUL8 Professional software platform, based on operations at an industrial collaborator's log sort yard.

The following activities were carried out:

1. **Data collection**: The test site was visited a few times to understand and map the process flow of logs.
2. **Model development**: A discrete event simulation model was developed to emulate the current operation. (Each simulation run emulates 4 weeks of operation.) The model was verified and validated using the collaborator's data.
3. **Scenario evaluation**: A number of "what-if" scenarios were developed and then evaluated by quantifying the impact of changes.
4. **Model extension**: Another version of the simulation model was developed in order to simulate the operations of a log sort yard that includes scanner scaling activities and to evaluate the impacts of scanner scaling (instead of manual scaling) on the yard's operation, volume throughput, and machine operating cost.
5. **Evaluation of the new model**: A base case scenario was developed and tested to analyze the impacts of changes in machine utilization. The scenarios were compared in terms of impacts on the volume throughput, the required machine hours, the operation's total cost, and the cost per cubic metre of logs processed in the yard.

The model development activities have built on previous work at FPInnovations on the topic of sort yards modeling (Jung et al. 2015, Nadimi et al. 2016).

2.1 Data collection

The collected data included historical production data and operational data such as process times, travel distances, and machine KPI. The following methods were used to collect operational data at the industrial collaborator's log yard:

- **Detailed on-site time study**: A detailed time-and-motion study was conducted to quantify process times associated with mobile equipment undertaking different activities.
- **Distance calculations**: Distances in the log yard were calculated by using FPInterface (a GIS-based software developed by FPInnovations), and were based on yard layout.
- **Storage capacity estimation**: The storage capacity of the yard and each storage area, were estimated based on an aerial view of the yard, the boundaries of each storage area, the length of the logs, the dimension of the piles, and their orientation. The pile density ratio was measured based on pictures of cross sections of sample piles.
- **Historical data analysis**: Historical data were used to identify the characteristics of log arrival to the yard (i.e., truck and/or bundle entrance rate, and log sort distribution in each load), log handling machinery, inventory in the yard, and log exit from the yard (i.e., exit time and volume from each log sort).

2.2 Model overview

SIMUL8, a product of the SIMUL8 Corporation, is used for discrete event simulation. It provides basic building blocks, including work entry and exit points, work centres, queues, and resources. In the log yard simulation model, the function for each component is based on statistical distributions, which are derived from historical and collected production data. After developing and validating a simulation model, it is possible to test real scenarios in a virtual environment, for example by changing the parameters that affect system performance, by adding stochasticity and uncertainties, by carrying out extreme-load tests, and by verifying the proposed solutions by experimenting them, before selecting the best alternative.

In a log yard the processes and the movements of logs and mobile equipment are non-linear and dynamic, which makes the development of a simulation model much more complicated than developing one for linear processes, e.g., sawmills. In linear systems, the operations can be simulated by a visual model that follows the sequence of activities as they happen in the production line. In non-linear systems, while the operations follow the same logic, the processes and activities may change from one log end-use sort or to another, or even from one log to another (within the same end-use sort). Due to the complexity of log yard operations and the constraints of the Simul8 software, the model development is only possible by using a logical model. A logical model uses various algorithms to model the physical layout of the log yard and does not necessarily provide a visual representation of the log yard, as can be seen in Figure 2.

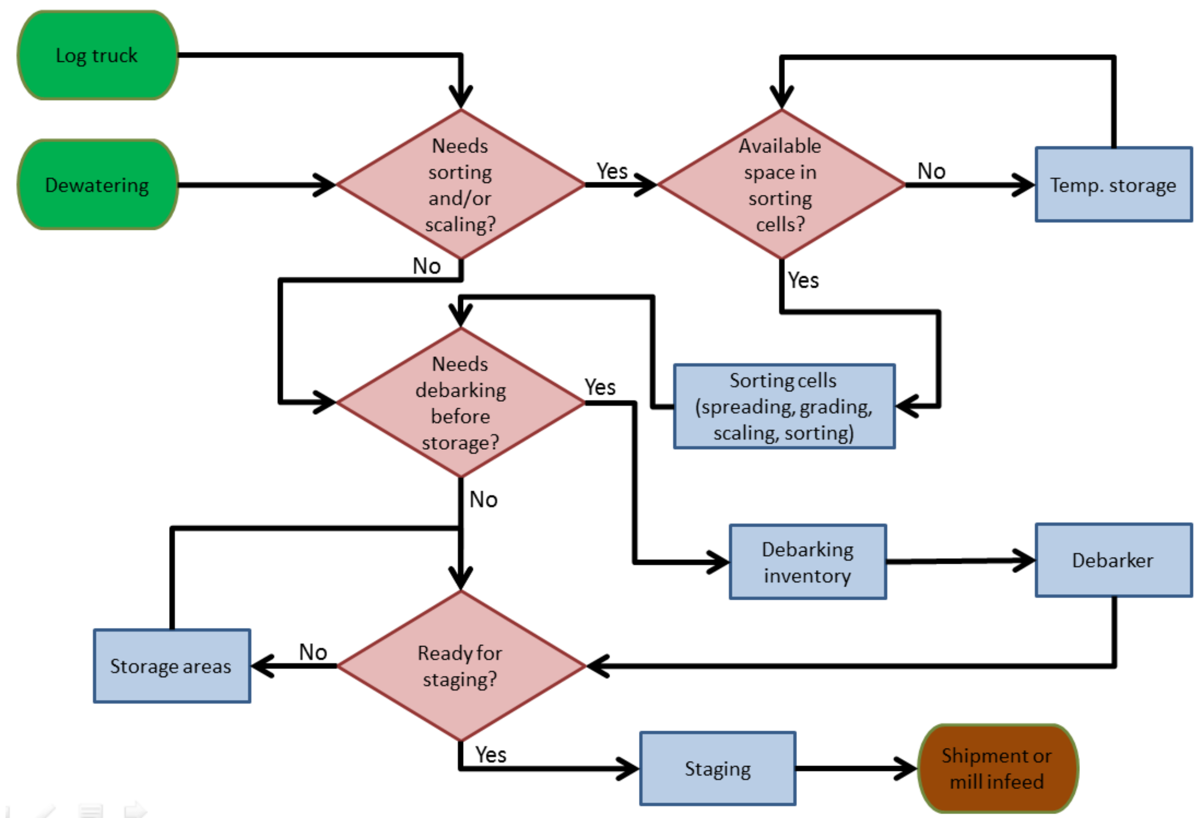

Figure 2. Simplified process flow of a log yard.

In this study, a logical simulation model was developed to emulate operations within a log yard or sort yard, including: arrival of logs by truck, truck unload, log scaling and sorting, arrival of logs by water, bundle retrieval, log storage, debarking, and log shipment.

Other events do occur in the yard, such as loading yard debris to dump trucks, but these were not included in the model because of the industry partner's preference, but also to reduce the model's complexity. Because the objective of this model is to serve as a decision-support tool for changes and capital investments at a tactical level, it works based on average and standard deviations of activities, and does not consider day-to-day and operational-level decision making. For example, the machinery in the yard is run by a contractor, and every day, the yard manager decides about the type of machines and the number of machines to be used the next day. Moreover, the machines may be hired for only part of a day. However, because those decisions represent operational-level work in the yard, the log yard simulation model assumes a fixed number of machines are employed full-time in the yard over the time scope of simulation.

2.3 Model structure and adjustable features

The log yard simulation model was designed to allow the log yard manager to evaluate the key factors that impact the business. The key factors include: log delivery, log mix, machine and operator parameters, yard layout, road condition, inventory, and log exit. The features of the log yard simulation model are:

- **Adjustable log-truck and dewatering arrival rate**: The model is capable of evaluating various arrival-rate scenarios. The truck arrival rate and log dewatering rate can be adjusted independently for each hour of operation. This allows the user to evaluate how the log yard responds to changes in log arrivals at different times throughout the day.
- **Adjustable load combination**: The user can configure the load combination on each log truck and in each dewatered log bundle, as well as the probability of each load type occurring. The user can create up to 20 different log-truck types and 40 different log bundle load types. Each load type can contain up to 200 end-use sorts. This feature allows the user to evaluate the potential impacts of different load types.
- **Machine and operator parameters**: Machine and operator parameters can have significant impacts on the productivity of a log yard. Increasing the travel speed and reducing processing times can increase productivity. The machine and operator parameters (speed and lift capacity) used in this model, and the process times considered for each task, are adjustable.
- **Yard layout**: One of the greatest challenges in a log yard is creating a layout that maximizes flexibility while minimizing material handling. The log yard simulation model developed in this study allows the user to evaluate the effects of moving key pieces of the infrastructure around the log yard, including: log-truck unload station, log surge, sorting cells, storage areas, debarking inventory, debarker, dewatering station, and log-staging area for shipment.
- **Road condition**: The road condition in the yard can affect the travel speed of the vehicles. While there is a cost associated with road improvements, low quality roads can have negative impacts on travel speeds of the machines in the yard. The log yard simulation model includes a road condition profile that allows the user to change the machines' travel speeds in different parts of the yard.

- **Inventory**: Another parameter that can affect a log yard is the yard inventory, including the initial inventory in the yard as well as log arrival by truck and water retrieval. The yard simulation model includes an initial inventory profile and an inventory storage rule profile. The initial inventory profile indicates the initial volume of each end-use sort and its storage location on the yard, and the inventory storage rule profile indicates if a certain end-use sort can be stored in a specific inventory area or not. Inventory profiles as well as storage capacities in the yard can be altered to analyze different scenarios. Each storage area also has a number of designated piles, in which only one type of product can be stored in each pile, which prevents the storage area from being filled with any more than 50 end-use sorts.
- **Log exit from the yard**: The log yard simulation model was designed to evaluate the impacts of changes in the shipment information. The user can alter the number of shipments, shipment size, shipment time, and required machinery, and the end-use sort combination destined for each customer.
- **Scanner scaling station parameter**: The version that includes a scanner station can also be adjusted (scanning speed and maximum number of sorting bins).

2.4 Model implementation

The simulation model developed in this study is very flexible, with many components that can be modified through an input file defined in Microsoft Excel. In order to build and run a new scenario, all the user needs to do is to upload the new Excel file into the simulation model and run the model with the new features. It takes less than 5 min to upload a new input file and run the model to emulate 4 weeks of operation. After that, the user can extract yard KPIs, such as log throughput and required machine hours.

The results generated by the model are in tabular format and are saved within the software platform. However, they can easily be exported as a .csv or .txt file, which can be copied into an Excel file for further analysis. The simulation model provides 3 different result tables:

- Trace log vehicle – details of all the movements of the vehicles in the yard.
- Trace log bundles – details of all bundles entering the yard (load types for truck loads and water bundles).
- Trace log – details of logs going into inventory from the sorting cells.

On a typical computer, running with Windows 7, an operation system of 64-bit, CPU of 2.10 GHz, and 8 GB of memory, it takes an average of 10 to 15 sec to run 4 weeks of data through the simulation model (comprised of 5 working days/week and one 12-h shift/day).

3 Model Evaluation and Scenario Analysis

In this study, a base case was developed to represent the current operations of the log sort yard. The base case was evaluated for three different months, because the industrial partner considered the operations were quite different from one month to another, and because these months were representative of the overall yard operation. Then, a number of capital improvement scenarios were discussed in order to analyze the impacts of changes in the yard.

3.1 Model verification and validation

In typical simulation studies, when there is an existing operation, the first step for model evaluation and preparation for scenario analysis is to develop a base case, which represents the existing system. By comparing the base case and the actual operations, it is possible to evaluate the precision of the model and, if required, understand the reasons behind the variations.

3.1.1 Data and assumptions

The model was run for 4 weeks, without any warm-up period. As the initial inventory represented the actual condition of the yard at the beginning of the simulation time, there was no need to consider a warm-up period in this model. The input file was filled, mostly using available data; however, because some data was not available, and all the processes could not be simulated in the model, some assumptions were made.

First, the load types (i.e., log-truck and dewatering) were identified according to the historical records. The arrival rates for both entry points were set, so the total volume coming into the yard was similar to reality. For example, in the first evaluated month, on average, two truckloads of log were delivered to the yard per hour, meaning that every 30 min a log truck entered the yard. Also, one bundle was retrieved every 6 to 7 min, resulting in an average of 9 bundles retrieved per hour.

Operation times (log-arrival rates, load combinations, initial inventory, and shipment information and requirements, etc.) was configured based on observation and estimation, as described in section 3.1. In this project, the base case was developed for three different periods, each covering 4 weeks, and it assumed a different number of log yard machines in each case. In the yard, vehicles are owned by a contractor, and the number of required machines is determined by the yard manager on a daily basis. Every day, the yard manager orders the number of machines and specifies the hiring time (which can be only part of a day). During the hiring time, the contractor charges an hourly rate for each machine, whether it is working or not. So, the yard manager tries to minimize the handling cost ($/m^3) in a way that there is always work lined up for the machines, and tries to avoid keeping the machines waiting (idling). In this context, the number of vehicles is not very critical in this case study, because the contractor is paid for the required hours only, and the objective is to have all the work done. The machine parameters used in this model are shown, for each month, in Table 1. The numbers are selected to ensure that all the required activities could be completed with available resources.

Table 1. Machine parameters used in the model

Vehicle	Vehicle speed (km/h)	Lift capacity (m^3)	Machines available		
			Month 1 (no.)	Month 2 (no.)	Month 3 (no.)
Stacker	14	60	4	4	3
Wheel loader	21	15	2	2	3
Butt-n-top loader	5	N/A	1	1	1
Grader	N/A	N/A	1	1	1

For the yard's existing inventory, the industrial partner uses estimations and the inventory levels are not recorded precisely. In this study, the inventory in the yard was estimated from the available reports, and adjusted according to the shipment load requirements (to make sure there is enough volume of each sort in the yard to fulfill the customer orders). Another assumption was that for each end-use sort, if the average piece volume was unknown, it was considered to be 1 m^3/log.

Table 2 shows an example of a shipment recipe. Shipment information was extracted from the shipping bills provided by the industrial partner. Only end-use sorts loaded from the land were considered, because an extensive portion of the loads are loaded directly from the water.

Table 2. Example of a shipment recipe

End-use sort	Product #	Required volume (m3)
134P	68	1 493
210	46	459
210P	73	467
227P	76	318
228	19	682
228P	77	1 205
229	20	1 342
229P	78	3 717
266P	83	75
627	63	868
627P	87	175

3.1.2 Base case results

The results of the machine cost estimated by the model and comparison with the actual cost of operation are displayed by month in Table 3. Balancing machine hours in order to avoid unnecessary idling but also to meet handling requirements in the yard is managed on a daily basis and based on experience, and is not the intent of this model. In addition, besides its own operation, the yard usually handles shipments as a contractor for other companies. In this case, that handling work is not considered in the model, but it actually uses the same machine resources. In this study, the KPI used to evaluate the performance of the log yard operation include the total active time of the machines, or the total machinery expenses (active time x renting charge/h), or machine cost of log handling ($\$/m^3$).

For confidentiality concerns, the details about the machines, utilization, yard throughput, and the financial information have not been displayed in this report.

The model simulated a simplified version of the operation and did not include all the activities in the yard. As a result, the following adjustments were considered during the test and validation:

- 25% idling time for the stackers and wheel loaders
- 1.5% more work time for stackers for each 1000 m^3 of logs leaving the yard
- 15% more cost for other machines and activities that were not considered in the model (labour, mechanic, debris management, etc.)

In each test, the simulated processed volume was found to be within ±5% of the actual processed volume in those months.

Table 3. Model cost versus the actual cost

Vehicle	Month 1	Month 2	Month 3
Stacker (# of machines)	4	4	3
Wheel loader (# of machines)	2	2	3
Ratio of the operation cost estimated by the model to the actual monthly operating cost	1.13	0.84	1.12

The model also provides a detailed list of all the vehicle movements in the yard, including the origin, the destination, the start and end times, the activity time and type. Table 4 displays a few examples of vehicle activity details.

Table 4. Examples of vehicle activities in the log yard

Vehicle	ID	Origin	Destination	Distance (km)	Time Start (min)	End (min)	Total (min)	Activity [a]
Wheel loader	2	Debarking station	Unload station 1	0.433	51.79391	53.28445	1.49053	Call
Stacker	1	Debarking station	Shipping area	0.275	51.81112	52.98969	1.17857	Transport
Wheel loader	1	Debarking station	Debarking station	0.342	52.21163	52.57289	0.36126	Work
Stacker	2	Debarking Station	Debarking station	0.342	52.23563	52.97258	0.73695	Work
Wheel loader	1	Debarking station	New	0.342	52.57289	53.55003	0.97714	Call
Stacker	1	Shipping area	Shipping area	0.275	52.98969	53.18969	0.2	Work
Stacker	1	Shipping area	New	0.469	53.18969	55.19969	2.01	Call
Wheel loader	2	Unload station 1	Unload station 1	0.433	53.28445	54.19939	0.91494	Work

[a] "call" = empty travel time to start a task. "Transport" = loaded travel time. "Work" = work in one location, e.g., spreading logs into a sorting cell, or picking a load from the crane at the dewatering station.
Another activity is "Go Home", i.e., there is no task to do so the vehicle goes back to its base to wait.

3.2 Possible scenarios

In FPInnovations' log yard simulation model, it is possible to run several potential improvement scenarios, evaluate their outcomes, and compare their impacts on the yard's KPIs, such as machine utilization, total machine travel distance, and total machine hours. Each of the following scenarios, or a combination of them, can be tested:

(1) Evaluate the impacts of altering the yard layout.
(2) Evaluate the effects of changing the number of machines.
(3) Analyze the effects of changing the road conditions.
(4) Explore different throughput scenarios.

3.2.1 Evaluate the impacts of altering the yard layout

The sort yard we evaluated consists of a truck unload station, a number of sorting cells, a number of log storage areas, a water retrieval station, a debarker, and a shipping area. The placement of the key yard components, such as the sorting cells and the debarker, affects the efficiency of material handling, machine utilization, and total machine time. An optimal layout facilitates balance between the movement of the wheel loader and stacker around the yard as they conduct their various tasks. For example, positioning the sorting cells close to the truck-unload station and close to the main external roads reduces machine time during truck unloading and log spreading into the sorting cells.

However, the trade-off is that the wheel loaders and stackers will need to travel longer distances to transfer sorted logs to the storage areas. With a similar logic, if the debarking station is placed just next to the shipping area, it can help minimize travel distance for moving debarked logs; but, on the other hand, on average, the bark-on logs will have longer travel distances.

FPInnovations' log yard simulation model can examine impacts of changes to the layout by using a new distance matrix.

Three scenarios were tested. These scenarios imply changing the location of the debarker to three different storage areas,[1] while the debarker location becomes the storage area:

(1) Scenario 1 → Debarking inventory
(2) Scenario 2 → XM shop
(3) Scenario 3 → Warehouse

Results are presented for each scenario in Table 5. Even though there are variations from one month to another, it is clear that in Scenario 3, in which the debarker is moved to the Warehouse storage area, is the best option because it results in the cost saving of 10 to 19% per month. Since a significant volume of logs goes directly from the dewatering station to the debarker, before going to the shipping area, moving the debarker closer to both areas is logical, if the storage capacity is not affected (which can be prevented by moving some storage capacity to the actual location of the debarker). The cost of changing the location should be calculated to determine full return on investment.

Table 5. Alternative yard layout: cost results

KPI	Scenario	Month		
		1	2	3
Potential cost saving in the month (%)	1 (Debarking inventory)	4	3	7
	2 (XM Shop)	12	<1	6
	3 (Warehouse)	15	10	19

3.2.2 Evaluate the effects of changing the number of machines

In this scenario, it is possible to evaluate the impacts of changing the number of machines on the performance of the log yard. While increasing the number of machines can result in a faster flow of logs within the yard, it can also reduce the machine utilization. Scenario analysis can help the log yard manager to determine the number of machines that results in a balance between process flow and machine utilization.

3.2.3 Analyze the effects of changing road conditions

This scenario was not evaluated in the project because the yard's roads were already in good condition. However, in yards with lower-quality surfaces, the yard manager may want to explore this option. The condition of the roads that connect the various yard components significantly affects the travel speed of vehicles. Improving the road condition requires economic investment.

[1] "XM shop" and "Warehouse" are local names that describe specific areas in the yard.

Without a proper decision support tool, it is difficult to estimate any trade-offs in productivity between investment in road improvement and no investment. The log yard simulation model will help the yard manager to explore and evaluate the impacts of different road improvement scenarios on machinery KPI, and make informed decisions about investing in the road and yard surfacing projects.

3.2.4 Explore different throughput scenarios

A change in yard throughput is another interesting scenario that can be analyzed using the log yard simulation model. The rate of truck arrival and water retrieval of logs can be increased, and the number and the capacity (size) of shipments can be altered to build different what-if throughput scenarios. The simulation model makes it possible to test whether the yard machines, storage areas, and debarker can handle additional and faster movement of logs or if an increased throughput will result in bottlenecks in one or more areas. This kind of scenario was not tested in this project; however, the model has this capability.

4 Scanner Scaling

In Coastal BC, when there is a need to scale and grade each individual log, the forest industry has to use manual scaling. In Canada the availability of log scalers and graders is limited, the manual scaling process is time consuming, and there are concerns about the safety of the process. As a result, in recent years, companies have shown interest in evaluating other options, such as automated log scaling methods.

New technologies and automated log measuring methods are available (Dyson, 2016a). One of the most popular automated log scaling methods is laser scanning, which has been used for log scaling purposes in Europe for over 20 years. In Canada, laser scanners are being used at sawmill infeed decks to optimize log breakdown (Dyson, 2016b).

There are many benefits associated with using scanner scaling, including: improved scaling speed and accuracy, improved safety and working condition for scalers, reduced dependency on manual scaling, reduced cost in operating machinery in the log sort yards, and improved log value.

For more information about regulation of using scanner scaling, refer to Dyson (2016b) and Dyson (2015).

4.1 Potential utilization scenario

In a recent study (Fillion, 2017), various scenarios were identified in order to evaluate the possibility of using laser scanning to scale the logs at sawmills. One of those scenarios – a measuring station – can be adapted to a sort yard situation. The scenario suggests a laser scanner measuring station would replace all the sawmill's current activities linked to scaling. As displayed in Figure 3, this scenario proposes the establishment of a measuring station where logs are unloaded from the trucks into a transfer area leading to a step-feeder. The logs then are electronically scanned/scaled and sent to the appropriate bins. Once a bin is full, a loader transfers its logs to the storage areas in the yard.

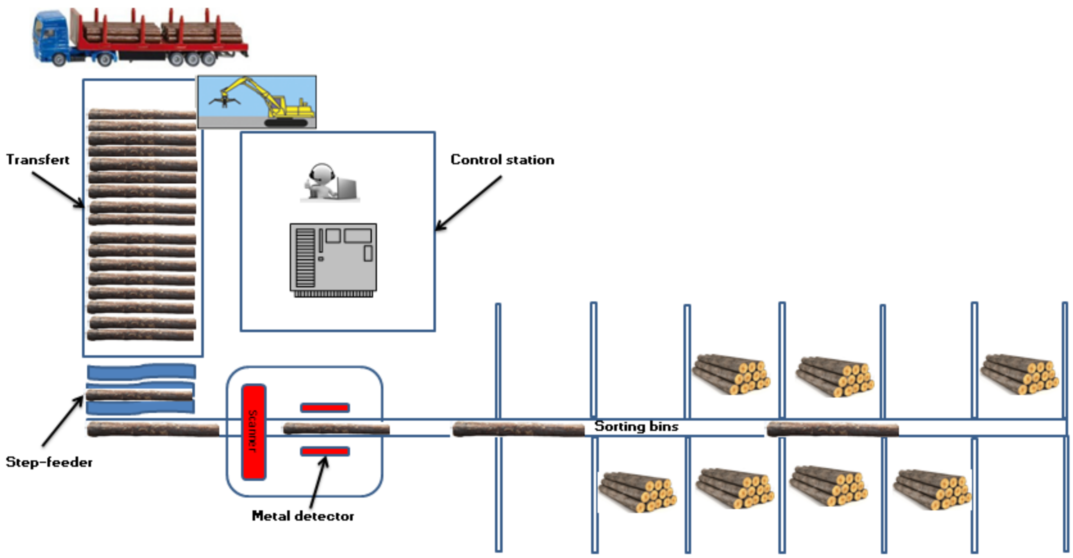

Figure 3. The flow of logs in a sawmill with a scanner station.

4.2 Logistics case study

The objective of the case study presented here was to evaluate the impacts of using laser scanning to scale logs on yard logistics. The simulation model described in Sections 3 and 4 was adapted to replace the sawmill's manual sorting and scaling activities by a scanning station. As the technology actually does not offer the possibility to identify the species, there is still a human component needed in the process; because of that, the time to process a log was evaluated at an average of 15 seconds.

The costing results are quite constant from one month to another and indicate potential operating cost savings opportunities (Table 6). However, this study did not consider the initial investment for such a station, which, according to Fillion (2017) is significant, up to several millions of dollars.

Table 6. Operating cost savings associated with a scanner station

KPI	Month		
	1	2	3
Potential operating cost saving in the month (%)	23	16	23

5. Conclusions

To assist Coastal British Columbia's log yards and sort yards improve their operations, FPInnovations developed and evaluated a log yard simulation model, and tested it in an industrial setting. The simulation model is a decision support tool that aids log yard managers in evaluating potential capital projects in a virtual framework, thus helping to minimize the risk of uncertain returns on investment. The development of the log yard simulation model was based on a log sort yard in British Columbia. However, the model is built within a generic framework that makes it flexible and customizable for other industrial locations. This is expected to reduce model customization and setup costs in future applications.

The log yard simulation model can be used to evaluate and compare infrastructure improvement projects through several what-if analyses, such as changing the log reception rate and load combinations, yard layout, road conditions, and yard throughput.

The log yard and sort yard simulation model was validated with industrial data. The validation shows the potential of this tool for use as a decision support system that can evaluate capital improvement scenarios intended to increase the efficiency of log yard operations, and thereby reduce costs and improve productivity.

Adding a laser scanner scaling option into the model framework is a new feature that will help decision makers evaluate if laser scanning is a worthwhile change to make. This study's results show clear potential operational gains; however, the cost of capital implementation for an automated scanner scaling system needs to be considered in order to justify this approach. Detailed cost analysis is needed for each particular yard operation, in addition to simulating the logistics, in order to fully evaluate the trade-offs and return on investment.

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Head Office

Pointe-Claire
570, Saint-Jean Blvd.
Pointe-Claire, QC
Canada H9R 3J9
T 514 630-4100

Vancouver
2665 East Mall
Vancouver, BC.
Canada V6T 1Z4
T 604 224-3221

Québec
319, rue Franquet
Québec, QC
Canada G1P 4R4
T 418 659-2647

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