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'The Good SIMaritans'
Simio March 2017 Student Competition - Pulp and Paper Business Logistics

MAJOR MODELING ASSUMPTIONS

- Average distance between logging operations and mills: we assumed the mills were located in the center of a 100 x 100 square mile grid. Assuming each grid houses 1 of the 100 total logging operations, we calculated an average distance from the center of 38.12 miles, which equates to a $137.23 per truckload trip (based on $0.12 per ton per mile and 30 tons per truckload)

		x-distance from center									
		45.00	35.00	25.00	15.00	5.00	5.00	15.00	25.00	35.00	45.00
y-distance from center	45.00	63.64	57.01	51.48	47.43	45.28	45.28	47.43	51.48	57.01	63.64
	35.00	57.01	49.50	43.01	38.08	35.36	35.36	38.08	43.01	49.50	57.01
	25.00	51.48	43.01	35.36	29.15	25.50	25.50	29.15	35.36	43.01	51.48
	15.00	47.43	38.08	29.15	21.21	15.81	15.81	21.21	29.15	38.08	47.43
	5.00	45.28	35.36	25.50	15.81	7.07	7.07	15.81	25.50	35.36	45.28
	5.00	45.28	35.36	25.50	15.81	7.07	7.07	15.81	25.50	35.36	45.28
	15.00	47.43	38.08	29.15	21.21	15.81	15.81	21.21	29.15	38.08	47.43
	25.00	51.48	43.01	35.36	29.15	25.50	25.50	29.15	35.36	43.01	51.48
	35.00	57.01	49.50	43.01	38.08	35.36	35.36	38.08	43.01	49.50	57.01
	45.00	63.64	57.01	51.48	47.43	45.28	45.28	47.43	51.48	57.01	63.64

- Tonnage scale: 1 tree model entity = 10 tons. This made the model a bit more manageable since we didn't have the hardware to simulate 100s of thousands of model entities. On the other hand, it reduced some of the uncertainty since the case called for 25-35 tons per truckload, but we were only able to model 30 tons (or 3 model entities) per truckload since Simio does not allow for partial mode entities
- Single source of logging operations: again since we did not have the hardware to run 100 different logging operation objects, we simplified into a single source for all truckloads. As such, we could not simulate the variable distances that would in reality exist between various logging operations and mills
- Since the case had inconsistent information regarding the number of daily truckloads in soft conditions (1-2 loads in the text vs. 3-5 loads in the table, both on page 5), we assumed 2 loads per day
- We split the simulation into three parts in order to be able to run the model. We found that during Jan-Mar and during Jun-Dec, the logging operations are producing more wood than the mills can process, the number of active entities within our model began to explode causing the simulation to run increasingly slowly
    - Frozen: we started with the base case inventory assumptions and 6 loads per day (we used the minimum to reduce the drag on computer resources)
    - Soft: we assumed 100% starting inventory since the frozen periods would have resulted in excess inventory and 2 loads per day
    - Dry: we assumed 0% starting inventory since all mills experience stockouts during the soft period and 6 loads per day

QUESTIONS FOR BASELINE MODEL

What is the total transportation cost for the system?

Based on our assumption of 38.12 miles for an average one-way trip, the total transport costs for the system was just over $23M.

Object Name	Data Source	Category	Data Item	Scenario	Days	Total (USD)
Main_Model	LogTransport	Costs	TotalCost	Jan-Mar	90	6,433,205.17
				Apr-May	61	1,456,696.45
				Jun-Dec	214	15,129,333.04
Grand Total						**23,019,234.66**

What is the average inventory at each of the mills?

The average daily inventory for Bright, Koala and PaperTech was 85132, 73469 and 45522 tons, respectively.

Object Name	Data Source	Category	Data Item	Scenario	Average
Mill_Bright1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	10,327
				Apr-May	3,952
				Jun-Dec	9,051
Mill_Koala1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	9,301
				Apr-May	2,844
				Jun-Dec	7,808
Mill_PaperTech1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	5,955
				Apr-May	2,368
				Jun-Dec	4,585

What is the total inventory holding cost?

The total inventory holding costs for the system was just over $10M. The detail by mill and by period is outlined in the table below:

Object Name	Data Source	Category	Data Item	Scenario	Days	Total (USD)
Mill_Bright1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	127,318
				Apr-May	61	33,564
				Jun-Dec	214	262,842
Mill_Bright1 Total						**423,724**
Mill_Koala1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	114,675
				Apr-May	61	24,156
				Jun-Dec	214	226,766
Mill_Koala1 Total						**365,597**
Mill_PaperTech1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	73,417
				Apr-May	61	20,110
				Jun-Dec	214	133,155
Mill_PaperTech1 Total						**226,682**
Grand Total						**1,016,003**

How much was spent on penalties for low inventory?

In our simulation, each mill experienced low inventory status 3 times. Inventory levels less than 20,000 tons were designated as low as per the case; we further assumed that inventory status reverted to ‘normal’ when inventory surpassed 25,000 tons.

Object Name	Data Source	Category	Data Item	Scenario	Days	Observations
Mill_Bright1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	1
				Jun-Dec	214	2
Mill_Bright1 Total						3
Mill_Koala1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	1
				Jun-Dec	214	2
Mill_Koala1 Total						3
Mill_PaperTech1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	2
				Jun-Dec	214	1
Mill_PaperTech1 Total						3
Grand Total						9

How many days are lost due to weather conditions?

We used a rate table to model the arrival rates for the truck loads, but we did not model uncertainty due to weather conditions.

Did any stock outs occur? If so, how many?

Across all mills, stock outs occurred 7 times in total. Bright and Koala experienced 3 each, while PaperTech only experienced 1 stock out. This was due to how we modeled truckload prioritization. Since PaperTech had the lowest inventory capacity and the highest digester rate, it reached low stock status first and thus received the highest prioritization. In the soft condition period, even the highest truck load rate of 2 loads per day (6 days a week) basically only allowed PaperTech to 'tread water' in terms of inventory levels. As such, the other mills inventories were depleted more often.

Object Name	Data Source	Category	Data Item	Scenario	Days	Observations
Mill_Bright1	StockOutTally	UserSpecified	TallyValue	Apr-May	61	2
				Jun-Dec	214	1
Mill_Bright1 Total						3
Mill_Koala1	StockOutTally	UserSpecified	TallyValue	Apr-May	61	2
				Jun-Dec	214	1
Mill_Koala1 Total						3
Mill_PaperTech1	StockOutTally	UserSpecified	TallyValue	Jun-Dec	214	1
Mill_PaperTech1 Total						1
Grand Total						7

What is the maximum amount of wood cut in any county?

Since we were only able to model a single source for all logging operations given hardware constraints, we were not able to model distributions at the individual logging operation level.

What is the average amount of wood cut by each logging operation?

In our simulation, 166,731 truck loads or just over 5M tons of wood was logged. As such, on average each logging operation cut about 0.5M tons of wood during the year. These figures correspond with number of days x truck loads x day x 30 tons per load x 6/7 to account for the one day off per week.

Object Name	Data Source	Category	Data Item	Scenario	Days	Total
TruckLoad	[Population]	Throughput	NumberCreated	Jan-Mar	90	46,879
				Apr-May	61	10,817
				Jun-Dec	214	109,035
			NumberCreated Total			166,731

What is the average waiting time at each scale house for incoming trucks?

Average waiting times for the scale at Bright, Koala and PaperTech were 7.5, 7.1 and 13.9 minutes, respectively. Again, the apparent discrepancy for PaperTech stems from how we prioritized truck load direction during the soft season.

Object Name	Data Source	Category	Data Item	Scenario	Days	Average (Hours)
Mill_Bright1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.15
				Apr-May	61	0.01
				Jun-Dec	214	0.14
Mill_Koala1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.16
				Apr-May	61	0.01
				Jun-Dec	214	0.13
Mill_PaperTech1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.12
				Apr-May	61	0.12
				Jun-Dec	214	0.31

How many crawler repairs occurred for the year?

Approximately 630 crawler repairs occurred during the year. This was calculated based on 365 days x 24 hours per day x 3 mills x 6 crawlers per papermill / 250 hours in between repairs.

How many days' production is lost due to stock out at each mill?

Unfortunately, we were unable to incorporate this measurement in our simulation in time for submission, but we intended to measure this using a tally statistic.

QUESTIONS FOR IMPROVED MODEL

Discussion of improvements:

- In the case, 1) the total transportation cost was a function of distance between the logging operations and the various mills and 2) the mills are assumed to be at the center of a 100 mile by 100 mile grid. As such, given that the mills are centrally located, close to one another, it was unclear to us how we might optimize the system around distance minimization or transportation cost.
- Instead, we focused on optimizing around the number of truck loads and tonnage per load. With a centralized logistics function, one truck might be able to pick up loads from multiple operations to ensure maximum capacity utilization, i.e. 35 tons per truck. This is our optimization strategy.
- Given that we were forced to scale down, i.e. 1 model entity = 10 tons, we were unable to directly simulate a 35 ton per truck model; instead, we modeled 40 tons per truck (with the commensurate change to the interarrival rate) and then took the average between the improved model and the original one.

- Assuming the same average distance from the center of 38.12 miles, that equates to a $160.10 per truckload trip (based on $0.12 per ton per mile and 30 tons per truckload)

What is the total transportation cost for the system?

We anticipated that since the transportation cost is a function of tonnage and distance that lowering the distance by increasing the tonnage will not change the transportation costs within the system. However, in reality operating fewer trucks should create some cost savings (even if there might be more wear and tear on the trucks with the higher usage).

How many trucks are needed to sustain operations?

By increasing capacity utilization within each truck to 100% or a full 35 tons per truckload, ~15% fewer trucks are needed in the improved system.

What is the average inventory at each of the mills?

The average daily inventory for Bright, Koala and PaperTech were relatively unchanged.

Object Name	Data Source	Category	Data Item	Scenario	Days	Average
Mill_Bright1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	90	10,336
				Apr-May	61	4,454
				Jun-Dec	214	8,803
Mill_Koala1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	90	9,408
				Apr-May	61	3,244
				Jun-Dec	214	8,022
Mill_PaperTech1	Digester.InputBuffer	Content	NumberInStation	Jan-Mar	90	5,961
				Apr-May	61	2,485
				Jun-Dec	214	4,849

What is the total inventory holding cost?

With average inventories relatively unchanged, it's not unexpected that inventory holding costs remained relatively unchanged as well.

Object Name	Data Source	Category	Data Item	Scenario	Days	Total (USD)
Mill_Bright1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	127,425
				Apr-May	61	37,220
				Jun-Dec	214	258,046
			TotalCost Total			**422,691**
Mill_Koala1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	115,992
				Apr-May	61	27,109
				Jun-Dec	214	235,180
			TotalCost Total			**378,281**
Mill_PaperTech1	Digester.InputBuffer	Costs	TotalCost	Jan-Mar	90	73,491
				Apr-May	61	20,762
				Jun-Dec	214	142,158
			TotalCost Total			**236,411**
Grand Total						**1,037,383**

How much was spent on penalties for low inventory?

Interestingly, in the new model, inventory reached low levels one fewer time for both Bright and Koala but 11 more times for PaperTech.

Object Name	Data Source	Category	Data Item	Scenario	Days	Observations
Mill_Bright1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	1
				Jun-Dec	214	1
Mill_Bright1 Total						2
Mill_Koala1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	1
				Jun-Dec	214	1
Mill_Koala1 Total						2
Mill_PaperTech1	StockLowTally	UserSpecified	TallyValue	Apr-May	61	13
				Jun-Dec	214	1
Mill_PaperTech1 Total						14
Grand Total						18

How many days are lost due to weather conditions?

Again, we used a rate table to model the arrival rates for the truck loads, but we did not model uncertainty due to weather conditions.

Did any stock outs occur? If so, how many?

Unfortunately, stock outs occurred much more frequently in this, increasing from 3, 3 and 7 to 8, 10 and 19 for Bright, Koala and PaperTech, respectively. This is likely due to the lumpier arrival of truckloads given the use of fewer trucks.

Object Name	Data Source	Category	Data Item	Scenario	Days	Observations
Mill_Bright1	StockOutTally	UserSpecified	TallyValue	Apr-May	61	7
				Jun-Dec	214	1
Mill_Bright1 Total						8
Mill_Koala1	StockOutTally	UserSpecified	TallyValue	Apr-May	61	9
				Jun-Dec	214	1
Mill_Koala1 Total						10
Mill_PaperTech1	StockOutTally	UserSpecified	TallyValue	Jun-Dec	214	1
Mill_PaperTech1 Total						1
Grand Total						19

What is the maximum amount of wood cut in any county?

Again, since we were only able to model a single source for all logging operations given hardware constraints, we were not able to model distributions at the individual logging operation level.

What is the average amount of wood cut by each logging operation?

In our simulation, 147,387 truck loads or just over 5M tons of wood was logged. As such, on average each logging operation cut about 0.5M tons of wood during the year. These figures correspond with number of days x truck loads x day x 35 tons per load x 6/7 to account for the one day off per week.

What is the average waiting time at each scale house for incoming trucks?

With fewer trucks in the system, average waiting times declined considerably.

Object Name	Data Source	Category	Data Item	Scenario	Days	Average (Hours)
Mill_Bright1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.10
				Apr-May	61	0.01
				Jun-Dec	214	0.10
Mill_Koala1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.10
				Apr-May	61	0.01
				Jun-Dec	214	0.09
Mill_PaperTech1	EntryScale.InputBuffer	HoldingTime	TimeInStation	Jan-Mar	90	0.09
				Apr-May	61	0.11
				Jun-Dec	214	0.24

How many crawler repairs occurred for the year?

Approximately 630 crawler repairs occurred during the year. This was calculated based on 365 days x 24 hours per day x 3 mills x 6 crawlers per papermill / 250 hours in between repairs.

What is the total cost improvement for the system, including inventory and transportation?

Given how we modeled both scenarios, there were no apparent cost savings in terms of inventory and/or transportation. However, in reality, we would consider the cost savings from running a leaner fleet of trucks. Additionally, the inventory holding costs are relatively minor when compared to the cost of prioritizing deliveries during states of low inventory and the cost of full stockouts. As such, if we were not only considering the logistics aspects of this scenario, we would consider increasing inventory storage capacity.

What other improvements to the system can you recommend?

As mentioned above, we would recommend modeling the savings from running a leaner fleet of trucks and the impact of increasing storage capacity to prevent stock low and stockout situations from occurring.

Like any model, this represents an approximation of the system. What are the potential problems with modeling the system as described?

For us, perhaps it was a function of our hardware and/or modeling technique (which may have been too resource intensive), but we felt that we could not simulate this system in its full detail. As such, it was less a question of what additional aspects of reality might we include, but how we could add abstraction to the modeled scenario in order to allow our models to run.

How many days' production is lost due to stock out at each mill?

Unfortunately, we were unable to incorporate this measurement in our simulation in time for submission, but we intended to measure this using a tally statistic.