Ore Haul Truck Scheduling Optimization

American Gypsum / Eagle Materials

PURDUE UNIVERSITY | Edwardson School of Industrial Engineering

Client Background

American Gypsum is a wallboard manufacturer, also known as drywall. They are the fifth largest market competitor alongside other major US drywall manufacturers. Their strategy focuses on quality, customer care, specialized products, and minimizing material waste through sustainability practices.

Eagle Materials is American Gypsum's parent company. Eagle owns a diverse portfolio of building and construction materials companies. There are more than 70 facilities across 21 US states that are owned by Eagle Materials. Some of the industries that Eagle provides materials for are wallboard, recycled paperboard, cement, ready-mix concrete, and aggregates.

Problem Statement

New Mexico

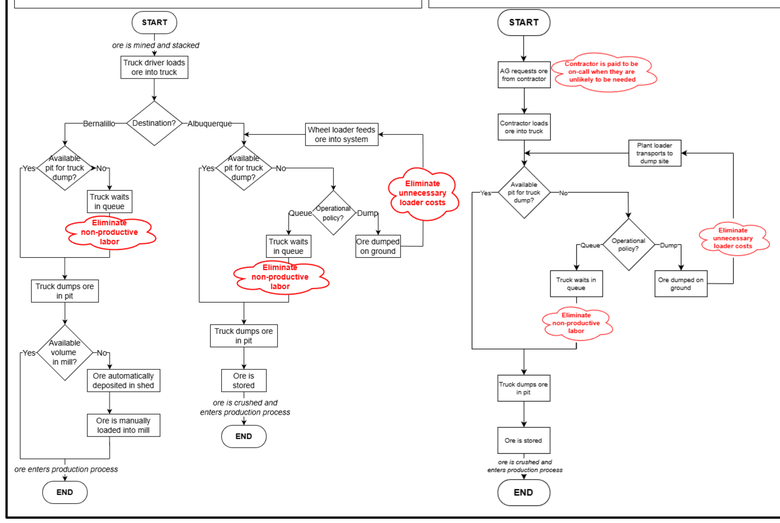
The two American Gypsum plants in New Mexico currently lack a truck scheduling system. This causes issues in the ore haul process, such as truck queuing at the production facility. This incurs the unnecessary labor and equipment cost of double-handling ore.

Oklahoma

The plant located in Duke, Oklahoma is planning an expansion. However, they do not understand if it is feasible to reduce delivery hours as demand increases, given the expected rise in contracted ore hauling costs. Like New Mexico, they lack a truck scheduling system and assume they will face similar issues with queuing.

System Models

New Mexico Delivery Process



Oklahoma Delivery Process

Methodologies

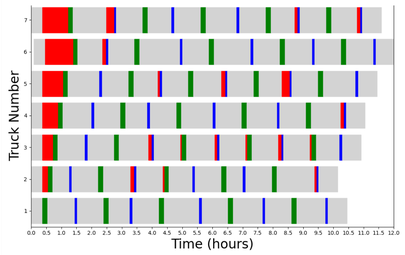
Shift Simulation

Given the measured and predicted variance for each location, the average lengths of many simulated shifts is recorded under different scenarios. In the below visualizations, the following tasks are considered productive:

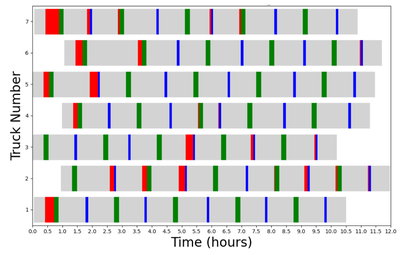
Gray – Driving **Green – Loading at Mine** **Blue – Dumping at Plant**

Efforts are directed towards minimizing **time in queue (considered waste, red)** through techniques such as staggering start times, shown on the right side.

Simulated shift with 7 drivers

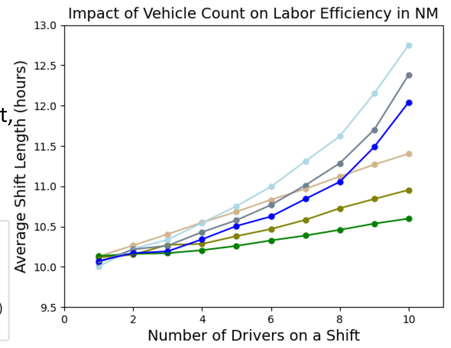


Simulated shift with 7 drivers, two start times



Reducing Congestion

With each scheduling technique (staggered start times), shift, and quantity of drivers on the same shift, the impact on overall drive time (active labor plus introduced idle time) is recorded from simulations.



Linear Program Integration

Ex. 65 deliveries/week required

marginal costs (hours of labor per driver added, from simulation)

$$\boldsymbol{M} = [11 \quad 11 \quad 11 \quad 11.5 \quad 12 \quad 13 \quad 15] \text{ man–hours}$$

pay multipliers (from contractor)

$$\boldsymbol{R} = [1.50 \quad 1.50 \quad 1.00 \quad 1.04 \quad \cdots \quad 1.00 \quad 1.04 \quad 1.50 \quad 1.50]$$

$$\text{schedule } \boldsymbol{X} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \text{ driver–shifts}$$

Objective: $\textbf{MINIMIZE } \boldsymbol{M(RX)^T} = \boldsymbol{799.5}$ equivalent man–hours

Results

INPUT

Production	
Demand	25000 tons/week

Trucks	
Quantity	10 trucks
Avg. Haul	30 tons/truck

Labor	
Night Rate	104% standard rate
Weekend Rate	100% standard rate
Weekend Night	104% standard rate
Overtime Rate	104% standard rate
Shift Start-up	0 minutes

Delivery Allowed (Y/N)	Day	Night
Monday	Y	Y
Tuesday	Y	Y
Wednesday	Y	Y
Thursday	Y	Y
Friday	Y	Y
Saturday	Y	Y
Sunday	N	N

Scheduling Procedure	
Selected:	1
	1 Identical Start
	2 Group Stagger
	3 Individual Stagger

SCHEDULE

Drivers per Shift	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day	10	10	10	10	10	0	0
Night	6	6	6	6	6	0	0

Costs	
Actual Labor Hours	1002
Cost (hrs of base rate	1030
Act. Haul (tons/week)	26400

Workforce	
Trucks	10
Drivers	16
Day Drivers	10
Night Drivers	6

Truck Scheduling Tool

- The tool has an Excel interface running an integer programming scheduling problem using the built in "Solver" tool in Excel
- The INPUT section accepts user input(s) to create a unique schedule catered to the plants current objective(s)
- The SCHEDULE section displays *the number of drivers per shift to minimize the driver-hours needed to meet the input demand and constraints*

New Mexico

- Recommendation: Stagger two groups start times by 1 hour at the start of the day to reduce unproductive queueing time at the beginning of the day

Impact for the Company

- By utilizing weekend shifts, driver-cost hours are optimized.

Oklahoma

- **624 driver-cost hours saved per year**
- Current driver demand: **534 driver-cost hours / week**
- Reduced driver demand: **522 driver-cost hours / week**

New Mexico

- ***2 Stagger Approaches:***
- 2 groups, starting 1 hour apart: **saves 1246 driver-cost hours / year**
- Every driver staggers 30 mins apart: **saves 1924 driver-cost hours / year**

Incoming Expansion

Oklahoma

- With the C-Line expansion, demand increases by 50%, and weekends will need to be worked to meet the demand
- Tool can be adaptive to the expansion's changing demand
- We recommend using:
  - Weekend and night shifts
  - 7 trucks / shift
  - 75 total driver-shifts / week
  - Contractor provided rates will provide the distribution of the shifts

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