Increasing Tractor Utilization Using Scripted Integer and Linear Programming

2018 Industrial Engineering Capstone Symposium

Grace McGee (PM) | Danarrius Broadway | T. Anginay Jones | Garrett Tallman

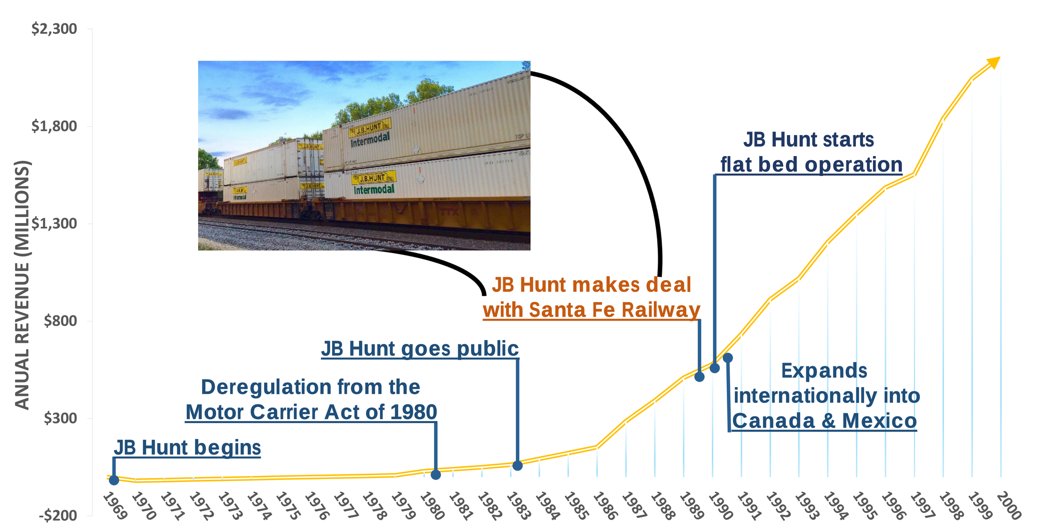
J.B. HUNT
UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

J.B. Hunt Transport

"J.B. Hunt Transport Services, Inc., a Fortune 500 company and one of the largest transportation logistics companies in North America, provides safe and reliable transportation services to a diverse group of customers throughout the continental United States, Canada and Mexico. Utilizing an integrated, multimodal approach, we provide capacity-oriented solutions centered on delivering customer value and industry-leading service."

About J.B. Hunt. (n.d.). Retrieved April 22, 2018, from https://www.jbhunt.com/company/

***Intermodal** is defined as the collaboration between more than one mode of transportation when moving a load to a destination. J.B. Hunt Intermodal (JBI) partners with five major North American rail carriers to provide intermodal freight solutions to customers via train and truck.*



Problem Definition

Drayage: *an intermodal industry term used to mean trucking*

Appointment: *a time scheduled by the customer detailing when JBI should arrive to the customer's location; can be a window of time or a set time*

Many appointments are completed during the peak hours, 6:00 A.M. to 4:00 P.M, highlighted in yellow on the graph below.

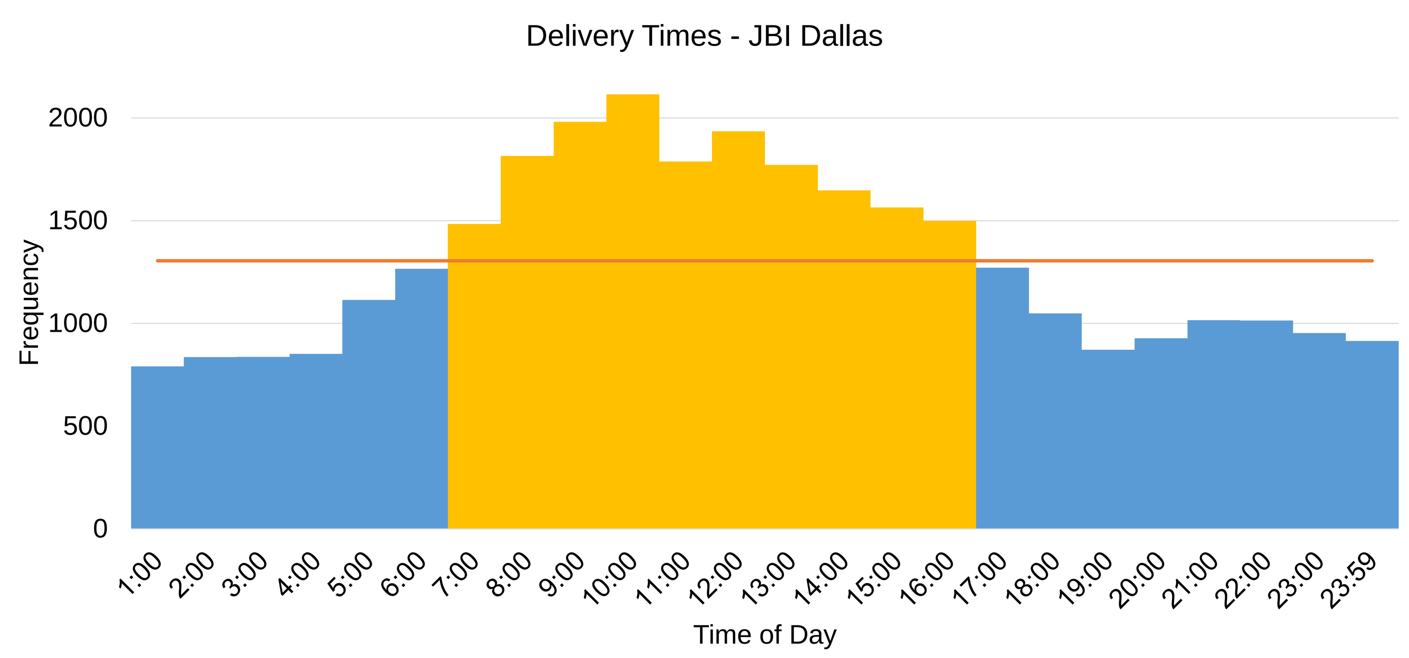
JBI wants their assets to be performing value-added tasks as often as possible, meaning tractor utilization should be as high as possible.

***Slip seating** is the practice of continually using a tractor, allowing one local driver to use the tractor for his or her shift early in the day and another driver to use the same tractor for his or her shift later in the day.*

Unused flexibility: *when an appointment is delivered during peak hours but its window included non-peak hours*

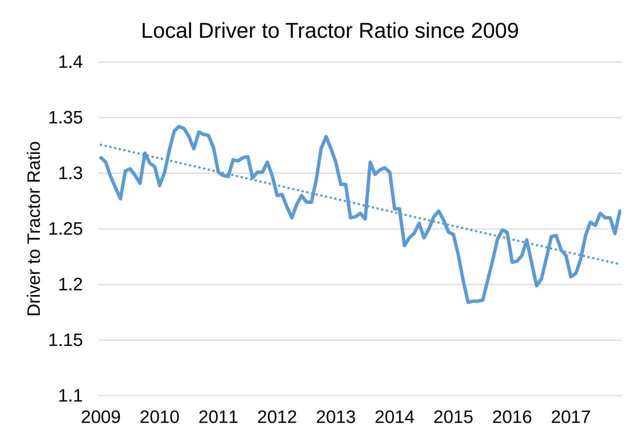
42% unused appointment flexibility during Q3 in Dallas

This realization encouraged our team to develop an alternative driver schedule to improve tractor utilization.



Process Description

Driver to Tractor ratio (D:T): *a fraction comparing the average number of employed drivers to the average number of JBI owned tractors over a specified period of time*

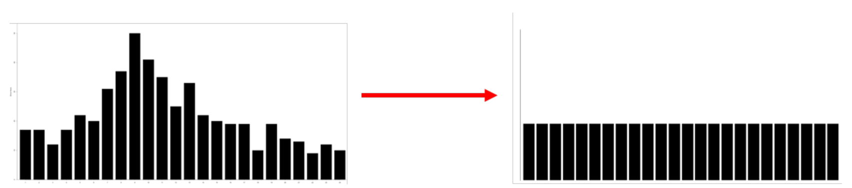


JBI has noticed a declining Local D:T over the years, sparking the interest in this project. We aim to improve D:T and tractor utilization by decreasing the number of tractors.

$$\frac{\text{Driver}}{\downarrow\text{Tractor}} = \text{Driver Tractor Ratio}\uparrow$$

Objectives:

1. Redistribute appointment completion times
   JBI currently completes many appointments during the peak times during the day, but we can work to minimize the variance of the number of appointments completed per hour in order to level out the demand, providing an increased need for night drivers and decrease tractor idleness.



2. Create a driver schedule capable of accomplishing new distribution
   Using a linear program, we can assign a custom driver schedule to the new appointment distribution. This will assist operations leadership in future driver planning and scheduling. To know how many drivers are needed for a specific hour block, we used a location specific productivity ratio.

***Productivity ratio**: explains the number of appointments each driver is able to complete per hour by location (formula below)*

$$\frac{X\ \text{stops per driver}}{1\ \text{weighted work day}} \times \frac{5\ \text{weighted work days}}{1\ \text{week}} \times \frac{1\ \text{week}}{X\ \text{average days worked}} \times \frac{1\ \text{day worked}}{X\ \text{average hours worked}} = \frac{X\ \text{stops per driver}}{\text{hour}}$$

Modeling Equations

X_i = Number of Appointments Assigned to be Completed in Hour i
μ = Average Number of Appointments per Hour
y_j^s = Start of Window for Appointment j
y_j^e = End of Window for Appointment j
y_j^a = Arrival Time of Appointment j
n = Number of Hours in Dataset
m = Number of Appointments

$$\text{Minimize: } \frac{1}{n}\sum_{i=1}^{n}(X_i - \mu)^2$$

$$\text{subject to: } y_j^s \leq y_j^a \quad \text{for } i = 1 \dots m$$

$$y_j^e \geq y_j^a \quad \text{for } i = 1 \dots m$$

Minimize Variance

X_{ij} = Number of Drivers Starting 5 Consecutive Day, 10 Consectutive Hour Work Week on Day i at Time j
D_{ij} = Number of Appointments Requiring Completion on Day i at Time j

$$A_{ijkl} = \begin{cases} 1, & \text{If Drivers Starting on Day } k \text{ at Time } l \text{ Complete Appointments on Day } i \text{ at Time } j \\ 0, & \text{o.w.} \end{cases}$$

P = Productivity Ratio (Appointments Per Driver Per Hour)

$$\text{Minimize: } \sum_{i=1}^{7}\sum_{j=1}^{24} X_{ij}$$

$$\text{subject to: } D_{kl} \leq \sum_{i=1}^{7}\sum_{j=1}^{24}(A_{ijkl} \cdot X_{ij}) \quad \text{for } k = 1 \dots 7, \ \text{for } l = 1 \dots 24$$

$$X_{ij} \in \mathbb{Z}^{+} \quad \text{for } i = 1 \dots 7, \ \text{for } j = 1 \dots 24$$

Create Driver Schedule

Results

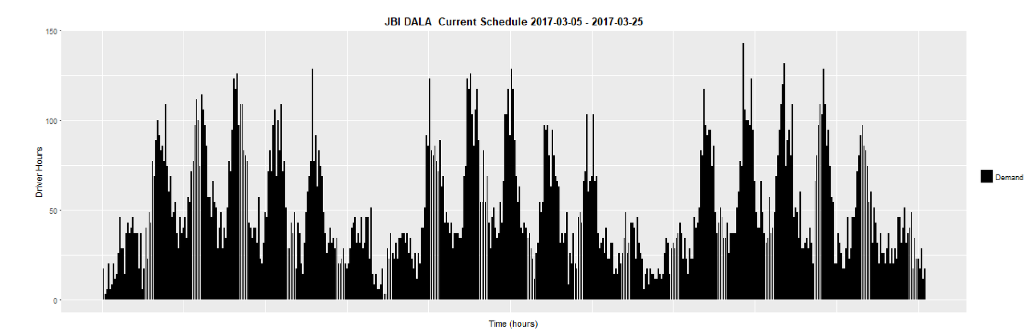
Driver Start--times Schedules

BEFORE

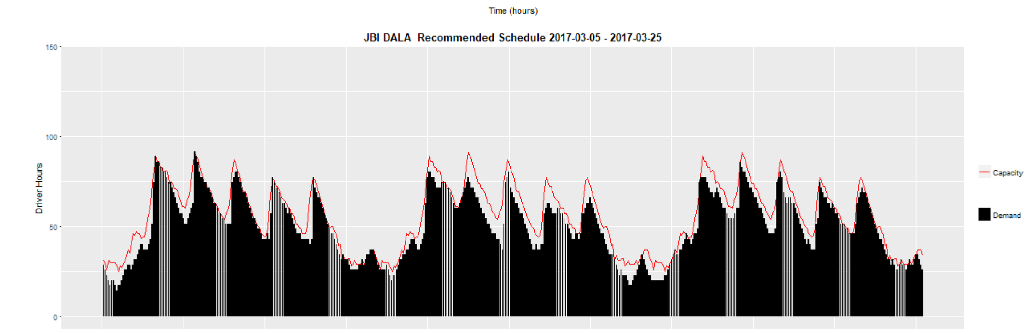
HOUR	SUN	MON	TUE	WED	THU	FRI	SAT
0	0	3	1	0	0	0	0
1	0	2	0	0	2	1	0
2	0	1	0	0	0	0	0
3	0	10	4	0	0	1	0
4	1	20	0	0	0	0	0
5	1	15	3	0	0	0	0
6	4	18	5	0	0	0	0
7	1	9	3	0	0	2	0
8	2	8	2	0	0	1	1
9	1	6	1	0	0	0	0
10	3	4	0	0	0	0	0
11	0	1	0	0	0	1	0
12	1	2	1	0	0	0	0
13	0	2	1	0	0	0	0
14	6	3	1	0	0	0	0
15	0	1	3	0	0	1	0
16	0	2	1	0	0	1	0
17	1	2	1	0	0	1	0
18	6	0	0	0	1	0	0
19	3	8	0	0	0	1	0
20	1	1	2	0	0	0	0
21	1	0	1	0	0	0	0
22	1	2	0	0	0	0	0
23	0	0	0	0	0	0	0

AFTER

HOUR	SUN	MON	TUE	WED	THU	FRI	SAT
0	0	6	0	0	0	1	0
1	0	6	4	0	0	0	0
2	0	11	2	0	0	1	3
3	1	6	0	0	4	1	1
4	0	4	0	0	0	0	8
5	2	10	0	0	1	0	1
6	0	12	1	0	0	0	1
7	0	9	0	0	0	0	0
8	0	5	1	0	0	2	1
9	0	2	0	0	3	0	1
10	0	3	0	0	0	0	1
11	0	5	0	0	1	0	0
12	1	6	1	0	3	0	4
13	3	3	0	0	1	4	2
14	3	0	0	0	0	0	5
15	3	5	2	0	0	1	0
16	4	6	1	0	3	0	0
17	3	3	0	0	3	0	0
18	1	1	1	0	1	5	0
19	0	1	0	0	2	0	0
20	0	0	1	0	0	1	1
21	0	1	1	0	0	0	0
22	7	1	0	0	0	4	1
23	2	1	0	0	0	2	2

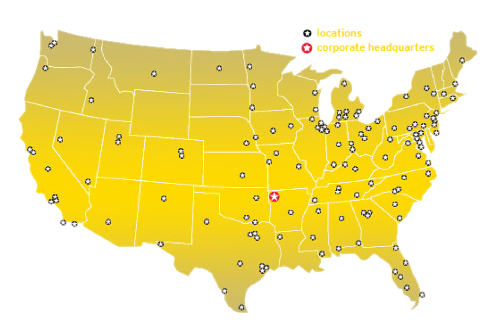


Before:
Variance: 1260.128
Mean: 60.54



After:
Variance: 453.707
Mean: 60.54

Our team created a new metric *% of Recommended D:T*
This metric allows JBI to compare tractor utilization across locations

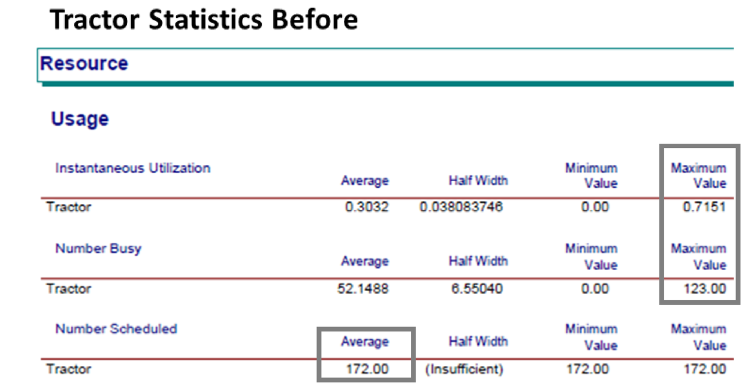


Charlotte (March)
Current Driver:Tractor – 1.14
Recommend Driver:Tractor – 1.36
% of Recommend = 83.8%

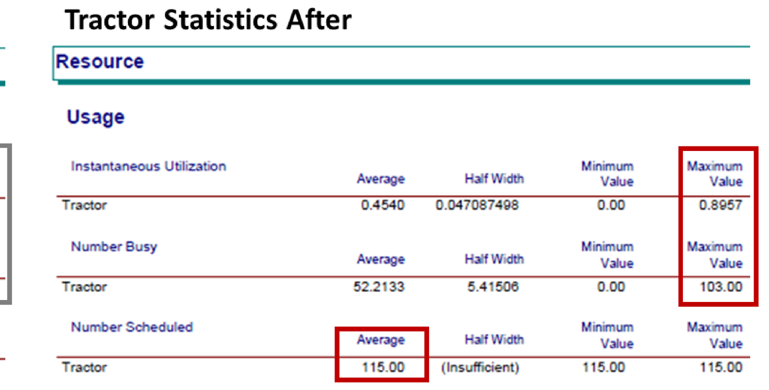
Dallas (March)
Current Driver:Tractor – 1.12
Recommend Driver:Tractor – 1.73
% of Recommend = 64.6%

Verification and Validation

Tractor Statistics Before



Tractor Statistics After



Cost Analysis

100% Bonus Depreciation							
EOY	BTCF	DWO	TI	T	ATCF	PW of ATCF	Cum PW of ATCF
0	$(106,500.00)				$(106,500.00)	$(106,500.00)	$(106,500.00)
1	$(4,800.00)	$106,500.00	$(111,300.00)	$(29,494.50)	$24,694.50	$22,048.66	$(84,451.34)
2	$(4,800.00)	$-	$(4,800.00)	$(1,272.00)	$(3,528.00)	$(2,812.50)	$(87,263.84)
3	$(4,800.00)	$-	$(4,800.00)	$(1,272.00)	$(3,528.00)	$(2,511.16)	$(89,775.00)
4	$(4,800.00)	$-	$(4,800.00)	$(1,272.00)	$(3,528.00)	$(2,242.11)	$(92,017.11)
5	$25,200.00	$-	$25,200.00	$6,678.00	$18,522.00	$10,509.88	$(81,507.23)

Cost Avoidance based on 100% Bonus Depreciation			
Current Fleet		New Fleet	
Fleet Size	195	Fleet Size	147
Cost to operate current fleet size over 5 years.	$(15,893,909.37)	Cost to operate with new fleet over 5 years.	$(11,981,562.45)
Cost Avoidance			$ (3,912,346.92)