Reducing Empty Costs of ReloCube Repositioning through Forecasting and Optimization

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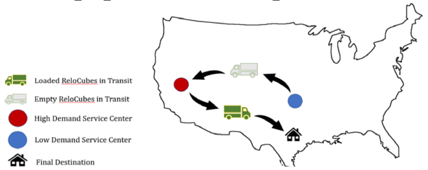
ABF Freight
An ArcBest Company

The ABF Freight U-Pack

ArcBest is a Fortune 1,000 company specializing in logistics and freight transportation by truck. ArcBest delivers integrated logistics solutions for a variety of supply chain challenges, including less-than-truckload services via the ABF Freight network. ABF Freight specializes in less than truckload shipping amongst its 240 service centers within the United States. One of ABF Freight's specialties is its U-Pack service, a self-moving service allowing customers to request ReloCube(s), 305 linear feet of high-grade steel container(s) to transport enough belongings to furnish a large room.



ABF Freight's U-Pack service struggles with repositioning costs that occur during equipment relocation to meet demand. The transportation of empty ReloCubes incurs empty costs associated with the miles traveled. ABF Freight is concerned that the current management of ReloCube repositioning results in too much of this empty movement.

Problem Definition and Approach

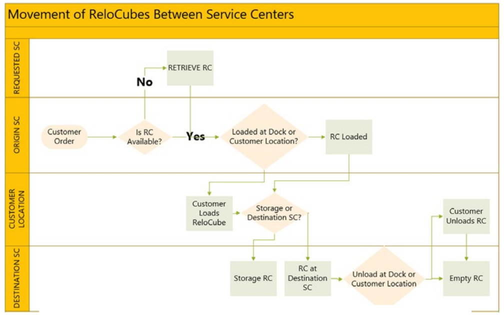
ABF Freight requested our team to provide recommendations to reduce the repositioning costs of empty ReloCubes between its service centers. Our teams recommendations include a ReloCube Tracker, a forecasting model, and an optimization model which takes the predicted demand and ReloCube Tracker to determine where ReloCubes should be placed.

ReloCube Tracker | Forecasting | Optimization Model

The ReloCube Tracker Model verifies the inventory of ReloCubes on a weekly basis. The Forecasting tool uses historical transactional data to predict demand on a weekly basis for a service center. The Optimization Model takes the inventory and predicted demand to calculate the optimal reposition moves to minimize empty costs. To assess and impact of the model, we used Empty ReloCube Utilization and the Allocated Empty Miles.

ReloCube Tracker

Two databases feed the ReloCube Tracker: a transactional data base and a ReloCube movement database. The transactional database provides information on the interactions between customers and the service centers. The ReloCube movement database provides information on the interactions between Service Centers. The swimlane diagram below represents how ReloCubes behave within the system. These events represented in the swimlane diagram feed from the variables shown below. These variables are implanted in the tracker through Visual Basic Applications.



Service Center *i*

J: New Empty RC at SC

K: New Loaded RC at SC

F: RC at Customer Location being Loaded

I: RC at Customer Location being Unloaded

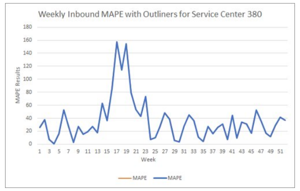
D: Empty RC in transit to destination SC

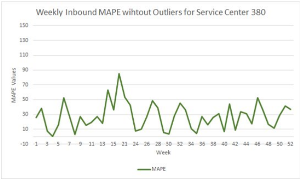
E: Loaded RC in transit to destination SC

B: New Empty RC entering SC

Forecasting

Demand was forecasted using Excel for each service center to allow ABF Freight to better predict equipment repositioning. Using historical data from 2016 to 2020, we built a forecasting tool where we used the upper and lower bounds of the demand. This provided general trends of when ReloCubes will be needed. To check for the accuracy of the demand, we performed MSE, MAPE, and RMSE. MAPE led to the removal of outliers to make more accurate predictions.





Optimization Model

The aim of the Optimization Model is to help us minimize the repositioning costs incurred from empty miles traveled. The parameters and decision variables shown below will alter the goal of minimizing repositioning costs.

Y_{ijw} = Number of empty RC delivered from demand satisfied SC i with a surplus to demand unsatisfied SC j in period w

I_{iw} = Number of RC kept in Inventory at SC i during period w

L_{ij} = Distance between demand satisfied SC i to demand unsatisfied SC j

S_{iw} = Expected Number of loaded RC emptied added to inventory based on RC ordered during Planning Period for SC i in week w

D_{iw} = Forecasted demand at each SC i during period w

$$I_{i,w-1} + S_{iw} - \sum_{j=1}^{222} Y_{ijw} + \sum_{j=1}^{222} Y_{jiw} - D_{iw} = I_{iw}$$

I_{i0} = Initial Inventory value for each service center

The Inventory Balance Constraint ensures that demand is met while also ensuring that inventory is used to its capacity.

$$\text{Min} \quad C\sum_{w=1}^{6}\sum_{j=1}^{222}\sum_{i=1}^{222} Y_{ijw} * L_{ijw} + E\sum_{w=1}^{6}\sum_{i=1}^{222} I_{iw}$$

The Objective Function minimizes the total empty costs the optimal network has.

To verify our model was more cost effective than ABF Freight's repositioning in 2019, we used different data inputs to see if increasing the number of ReloCubes in the system would decrease costs and if our forecast models would be a useful prediction that can minimize costs for that planning period.

Potential Annual Impact

Our model reduced repositioning costs by at least 64% and reduced empty Relocube movement substantially. By incorporating an inventory tracker, ABF Freight can avoid forecasting uncertainty within the supply parameter by simulating the live tracking of ReloCubes for increased visibility. If this is not possible, the forecasting tool is beneficial to forecast the inputs for the demand and supply parameters in the optimization model.

	2019 Performance	Historic Model	Historic Model Increased Inventory	Forecasted Demand Model	Forecasted Model Increased Inventory
Empty ReloCube Utilization	17%	18%	16%	9%	9%
Total Allocated Empty Miles Percentage	7%	3%	2%	1%	1%
Repositioning Cost Decrease		65%	67%	81%	82%