United Parcel Service
NAAFN - Ground

Senior Design
Final Presentation

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This presentation has been created in the framework of a student design project and it is neither officially sanctioned by the Georgia Institute of Technology nor the United Parcel Service.
Outline

• Client Description
• Problem Description
• Design Strategy
  – Truckload Demand Generator
  – Independent Lane Scheduling Model
• Integrated Approach
  – Stochastic Optimization
• Results
• Conclusion
Client Description
UPS North American Air Freight Network (NAAFN)

• Large Third Party Logistics (3PL)

• Product Offerings of NAAFN
  – Next Day
  – Second Day
  – Economy/Deferred Delivery

• Ground Truck Movements
  – Scheduled Movements
  – Ad-hoc Movements
Regional Hub Ground Network
Truckload Procurement Process

1. Determine Scheduled Moves per Lane
2. Build Routes to Cover Scheduled Moves
3. Obtain Carrier Bids for Routes
4. Award Route Contracts to Winning Bidders
Project Focus

Determine Scheduled Moves per Lane

Build Routes to Cover Scheduled Moves

Obtain Carrier Bids for Routes

Award Route Contracts to Winning Bidders
UPS’s Current Method

Determine Scheduled Moves per Lane

\[
\frac{\text{Average Weekly Demand}}{\text{Weekly Operating Days}} = \text{Moves per Day}
\]
Operational Process

Scheduled Routes are Executed Weekly

Scenario One
Demand < Scheduled
Incur scheduled truck cost

Scenario Two
Demand > Scheduled
Dispatch ad-hoc truck(s)
DAILY VARIABILITY
2007

LBS (MILLIONS)

100
120
140
160
180
200
220

MON TUE WED THUR FRI SAT

DAY OF WEEK
Design Strategy

Truckload Demand Generator

Independent Lane Scheduling Model

Integrated Model

Detailed Cost Estimation Model

Detailed Cost Estimation Model
Truckload Demand Generator

**Input**
- Shipment Level OD Demand Data
  - Includes: OD data, Day of departure, Actual weight, GAD weight, Miles

**Functionality**
- Chain Tables
  - Assigns OD freight to sequences of lanes
- Conversion
  - Convert to truckloads required on each lane each day

**Output**
- Demand Histogram
  - Trucks per lane per day
Design Strategy

Truckload Demand Generator

Independent Lane Scheduling Model

Integrated Model

Detailed Cost Estimation Model

Detailed Cost Estimation Model
Independent Lane Scheduling Model

**Input**
- Histograms from TDG
- Lane Cost Estimates
  - Ad-hoc
  - Scheduled

**Functionality**
- Independent Lane Scheduling Model

**Output**
- Number of moves to schedule on each lane per day

Minimize expected costs per lane per day
Ad-hoc Cost Estimation

- Multiple Linear Regression
- $R^2 = 0.752$

\[ Y_{AB} = (r_{AB})d + \sum_{i=1}^{n} [(IN_i)\alpha_i + (OUT_i)\beta_i] + C \]

Where
- $Y_{AB}$ = Ad-hoc cost from city A to city B
- $\beta, \alpha, d, C$ = Factor coefficients
- $r_{AB}$ = Distance in miles from city A to city B
- $IN_i, OUT_i$ = Indicates a move into or out of state $i$
ILSM Functionality

• Treats each lane individually
• Decides amount of moves to schedule ($T_S$)
• Distributions ($T_a$) approximated by TDG
• Lane Cost = $C_S \times T_S + E[C_{AH} \times \text{MAX}(0, T_A - T_S)]$

Where:

• $C_S$ = Cost of scheduled move on lane
• $C_{AH}$ = Cost of an ad-hoc move on lane
• $T_S$ = Amount of scheduled trucks
• $T_A$ = Amount of actual trucks needed
Detailed Cost Estimation

- Total Cost: Scheduled cost + Ad-hoc cost

- Two-Phase Approach
  - Phase I: Deterministic integer program
    - Covers complete lane moves with pre-existing routes
    - Minimizes scheduled truck dispatch costs
  - Phase II: Compute ad-hoc cost
    - Uses route schedule from phase I
    - Computes necessary ad-hoc moves and cost per day from historical data
ILSM Results

<table>
<thead>
<tr>
<th></th>
<th>Scheduled</th>
<th>Ad-hoc</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPS 2007</td>
<td>$70,900,000</td>
<td>$4,900,000</td>
<td>$75,800,000</td>
</tr>
<tr>
<td>ILSM</td>
<td>$63,900,000</td>
<td>$18,300,000</td>
<td>$82,200,000</td>
</tr>
</tbody>
</table>

- Possible Causes of Higher Cost:
  - Unbalanced routes
Design Strategy

- Truckload Demand Generator
- Independent Lane Scheduling Model
- Integrated Model
- Detailed Cost Estimation Model
- Detailed Cost Estimation Model

Diagram:

- Truckload Demand Generator
- Independent Lane Scheduling Model
- Integrated Model
- Detailed Cost Estimation Model

Diagram icons:

- UPS logo
Integrated Model

• Integrates Scheduling and Costing
  – Stochastic programming model
  – Uses pre-existing NAAFN routes and costs
  – Selects routes to execute weekly

• Sample Average Approach
  – Generates $n$ random weeks from TDG
  – Covers all moves in each scenario
    • With a route or an ad-hoc move

• Minimize Sample Average Cost per Week
Xpress Model

• Inputs
  – Pre-existing routes, route costs, ad-hoc costs, and TDG frequency histograms

• Functionality
  – Random variables represent CDF of histogram
  – Number of constraints = $n \times$ number of unique lane-day combinations
    • $n = 50$
      – Over 125,000 constraints
      – Run time of three minutes
**Integrated Model Results**

- **Results:**
  
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<tr>
<td>SA n=10</td>
<td>$33,000,000</td>
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<tr>
<td>SA n=50</td>
<td>$32,300,000</td>
<td>$37,100,000</td>
<td>$69,400,000</td>
</tr>
</tbody>
</table>

- **Concerns:**
  - Extremely risky to depend on unscheduled moves
  - Sensitivity of model to ad-hoc cost estimates
# Improvements

- “Scheduling” Ad-hoc Movements
  - One-way moves
    - Occur consistently throughout the year
    - Scheduled at ad-hoc price

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<th>Scheduled One-Way</th>
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<tr>
<td>ILSM</td>
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<tr>
<td>SA n=50</td>
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<td>$53,600,000</td>
<td>$15,800,000</td>
<td>$69,400,000</td>
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Conclusions

• Suggested Method
  – Integrated model

• Further Improvements
  – Scheduling one-ways

• Significant Potential for Cost Savings
  – Scheduling daily may save $6M annually
Recommendations

• Implementation
  – Estimate daily demand per lane from TDG
  – Generate new “candidate” routes
  – Estimate new route costs

• Solve Integrated Model to select routes for bids
Questions