The 2013 Supply Chain Innovations of the Year

Inventory Control for Highly Variable Demand

Dr. Tovey Bachman, LMI
Mr. Robert Carroll, DLA
Agenda

- Overview of Problems
- Summary of Innovations
- Solution Strategies
  - Peak Math Model
  - Next Gen Math Model
  - PNG Software Model
- Defense Logistics Agency (DLA) Case Study
  - Size of DLA
  - Size of Challenge
- Results/Outcome
- Summary

Industries
- Defense Department
- Apparel, Consumer goods
- Auto Industry
- Commercial Aircraft
- Electronics Manufacturing
- Food Industry
- Heat transfer and Fluid Handling
- Marine hardware
- Medical supplies
- Natural Gas
- Oil industry
Overview of Problems

• Supply chain management challenges
  – Critical items, high penalty for being out of stock
  – Highly variable demand
  – How to decide when to buy and how much?

• Two problems

1. Infrequent and irregularly-spaced (sporadic) demand
   • Demand for 5 units, then 50 units a year later, then 10 units 6 months later, etc.
   • Not economical to keep capacity on line to manufacture on demand
   • Items critical enough that some must be stocked

2. Frequent, but highly variable demand
   • Highly variable demand every month, one month 500 units, next month 10,000
   • Error in demand planning (100–200% or more)
   • Current commercial supply chain solutions do not work well
Summary of Innovations

1. Developed 1st Risk Management–Based Approach
2. 1st Problem Recognized: Sparse Demand
3. Abandoned Forecast-Based Approach
4. Developed Early Peak Algorithms
5. Testing
6. 2nd Problem Recognized: Frequent, Highly Variable Demand
7. Developed 2nd Risk Management–Based Approach
8. Developed Advanced Peak Algorithms
9. Peak + Next Gen = PNG Software

- Barchi Prize for Best Paper at 2004 MORS Symposium
- Benefits of Peak Proven
- PNG Implemented for 1st Client
Summary of Innovations

• Problems
  – Infrequent, irregularly spaced demand
  – Frequent, but highly variable demand

• One Solution: PNG
Problem to be solved: Inventory control for infrequent, irregular demand

Solution
- Order when inventory gets down to some % of Peak demand
- Order a quantity based on unit price

Min = (Price-based mult.) * (Peak demand)
Max = Min + (Price-based order qty.)

20% of innovation

How to get good values for multipliers & order quantity

80% of innovation
Peak: 1st Solution, Step by Step

1. Identify 5-7 price groups

2. Generate 1000s of possible (M, Q) parameter sets for each price group

3. Run 1000s of simulations with randomized historical orders for each (M, Q) parameter set

4. Calculate metrics for each parameter set (1000s)
   - customer wait time
   - inventory value
   - buyer workload

5. Run mixed integer program optimization

6. The Peak is the max required buffer of stock

   \[ \text{min level} = (\text{price group multiplier}, M) \times (\text{max buffer size}) \]
   \[ \text{max level} = (\text{price based order quantity}, Q) + \text{min} \]

7. Select best (M, Q) parameter set for each set of goals yields levels

LMI
Complex Problems. Practical Solutions.
2nd Problem to be Solved: Frequent, But Highly Variable Demand

Current Process

1. Demand Plan or Forecast
2. Variance
3. Theoretical Distribution
4. Order Quantity

Each step loses important information

Loss of information

Optimization based on incomplete data

Stock levels
- Forecasted leadtime demand
- Safety stock
- Order quantity

Suboptimal business outcomes
New Methods Use Empirical Distributions

Customer Orders (transaction history) →
Inter-arrival time histogram (for frequent demand)
Demand size histogram

→ Leadtime demand probabilities
Inventory position probabilities

Optimization

Stock Levels
Min Level
Max Level

Next Gen

More accurate metrics tradeoff yields better business outcomes

Each step retains important information
Next Gen: 2nd Solution, Step by Step

1. Build Histograms
   - Inter-arrival time
   - Demand size

2. Compute stock probabilities for every min/max pair
   - Max
   - Min
   - (Unequal) probabilities of stock at each level

2.a Compute demand probabilities

2.b Compute metrics for every min/max pair
   - customer wait time
   - fill rate
   - inventory value
   - buyer workload

3. Use metrics for every min/max pair in optimization

4. Optimize across items to build series of tradeoff curves

LMI
Complex Problems. Practical Solutions.
Solution Overview: Peak + Next Gen = PNG

Saves downtime, saves money, reduces workload, and increases client satisfaction
Solution Overview: Peak + Next Gen = PNG

- Tradeoff Business Metrics
  - Inventory values ($)
  - Wait time
  - Workload to procure new items

Single point addresses all three variables
Peak and Next Gen Demonstration

LMI PNG Modeling Suite
Defense Logistics Agency Case Study

Business Overview
- $21 billion inventory
- 131,000 requisitions per day
- 10,000 contract actions per day
- $44 billion annual sales

Distribution
- 23 million receipts and issues processed annually
- 25 distribution centers; 75 million sq. ft. of storage
- Distribution often to a “moving” address

5 million items, 9 supply chains
- Land systems
- Maritime systems
- Aviation systems
- Fuel/energy
- Industrial hardware
- Subsistence
- Medical
- Clothing & textiles
- Construction & equipment

Business environment
- Demand uncertainty due to changing budgets, maintenance programs, and world events
- Critical items are stocked, regardless of demand
- Many low production, long leadtime items
Infrequent demand or frequent, but highly variable demand lead to large forecasting errors
DLA: How to Segment Item Population?

- **Non-Forecastable**
  - Low Frequency Model
    - ~1.1 million items (76%)
    - Infrequent demand

- **Forecastable**
  - High Frequency/High Variability Model
    - ~285,000 items (20%)
    - Frequent demand
      - High variability
  - Forecasting Suite
    - ~65,000 items (4%)
    - Frequent demand
      - Low variability

Need inventory control methods appropriate for each segment of inventory.
DLA: Competition

Round 1

**Goal:** Inventory turnover

DLA assessed 24 methods for inventory control—all forecast-based methods.

DLA expanded competition – **PNG** beat all other inventory control methods.

Round 2

**Goal:** Inventory reduction

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Inventory $</th>
<th>Wait Time</th>
<th>Cash Outlays</th>
<th>% of Orders</th>
<th>Material Availability</th>
</tr>
</thead>
<tbody>
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<td>Best of other inventory control methods</td>
<td>−1.2%</td>
<td>70.7%</td>
<td>−4.4%</td>
<td>−5.9%</td>
<td>−10.7%</td>
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<tr>
<td>PNG</td>
<td>−7.1%</td>
<td>−3.6%</td>
<td>−7.5%</td>
<td>−40.9%</td>
<td>0.8%</td>
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</tbody>
</table>

DLA implemented Peak and Next Gen in January 2013 for 500,000 items with $1.5 billion sales and $3.3 billion inventory.
DLA: Decision Process Today

Make single decision to trade off inventory, customer service, and buyer workload to fit business objectives

13% inventory $ reduction
9% wait time reduction
32% workload reduction

5% inventory $ reduction
22% wait time reduction
48% workload reduction
On track to meet DLA goals of improving customer service and reducing buyer workload with less inventory

- Material availability, Dec 2012 to Sept 2013
  - Peak—up from 72.4% to 78.4%
  - NG—up from 84.9% to 87.4%
- Unfilled orders, Dec 2012 to Aug 2013
  - Peak—down from 55K to 40K
  - NG—down from 47K to 38K
- Monthly buys generated down 10% so far
- On-hand inventory running lower
DLA Case Study Lessons Learned

• Engage change agents to help shift the paradigm in the beginning
• Communicate the strategic vision and expectations to the business
• Involve the customer early – provide software or service
• Provide training and communicate expectations
• Coordinate extensively with IT and functional experts for customized ERPs

Collaboration between DLA and LMI enabled rollout in just 9 months
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- More efficient inventory management for items with high demand variability
  - Advanced algorithms retain key information in customer demand
  - Better customer service, fewer inventory $

- Single decision for managers to drive
  - Customer service
  - Inventory $
  - Procurement workload

- Solution exists in two forms
  - Software as a service
  - Software as a package

POCs: Tovey Bachman / tbachman@lmi.org / 703-917-7361
Robert Carroll / Robert.Carroll@dla.mil / 703-767-2663