DEFENSE LOGISTICS AGENCY (DLA)

INVENTORY ALLOCATION AND FORECASTING

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Agenda

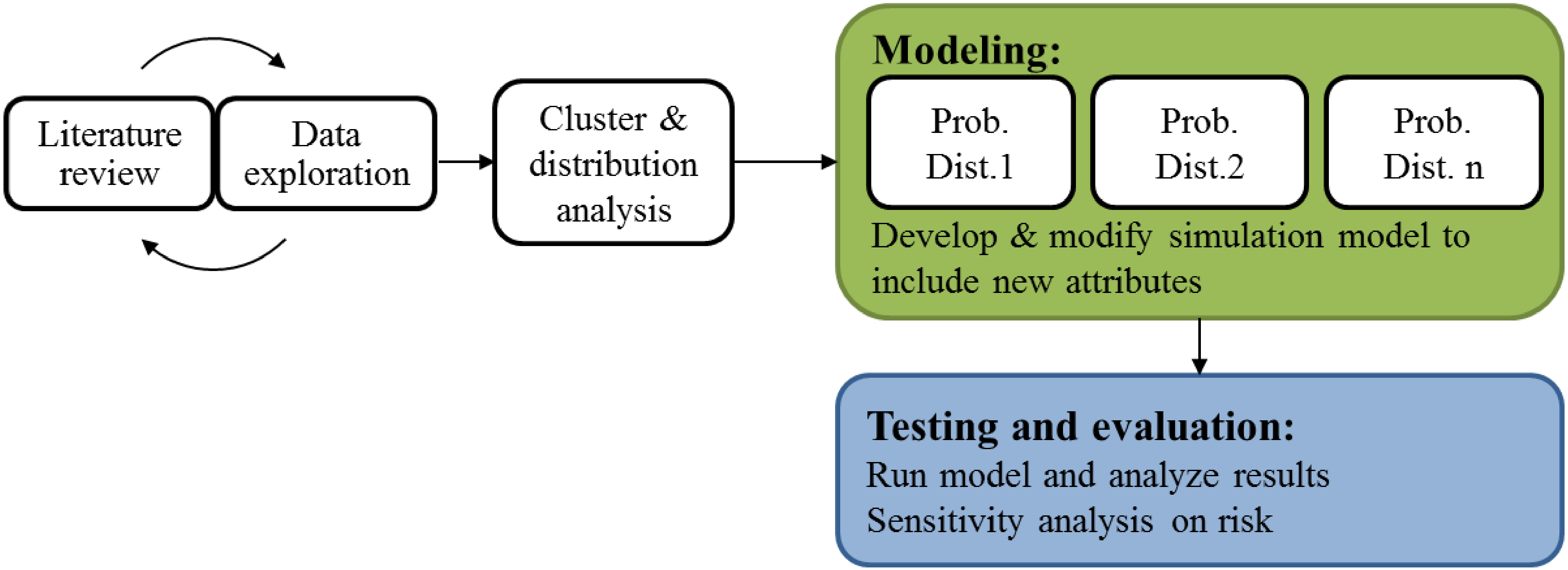
- Background
- Objective
- Data Exploration
- Cluster Analysis
- Model Development
- Testing and Evaluation
- Results
  - Summary
  - Recommendations

Background

- DLA is the Department of Defense’s (DoD) largest logistics agency. Provides support to Army, Navy, Air Force, Marine Corps, other federal agencies
- Sponsor was interested in Acquisition Advice Code (AAC) D, Replenishment Method Code (RMC) R
  - Able to be forecasted
  - Are being replenished

Objective

Be able to provide recommendations on **right size inventory** for Acquisition Advice Code D, Replenishment Method Code R inventory



Data Exploration - Metrics

- **Time Metrics (days)**
  - Administrative Lead Time (ALT)
  - Production Lead Time (PLT)
- **Variance Metrics**
  - Administrative Lead Time Coefficient of Variation (ALTV)
  - Production Lead Time Coefficient of Variation (PLTV)
- **Demand Metrics (count)**
  - Annual Demand Quantity (ADQ)
  - Annual Demand Frequency (ADF)
- **Value Metrics**
  - Demand Value (DV)
  - Annual Demand Value (ADV)
- **Output**
  - Back Orders Established (BOE)
  - Materiel Availability (MA)

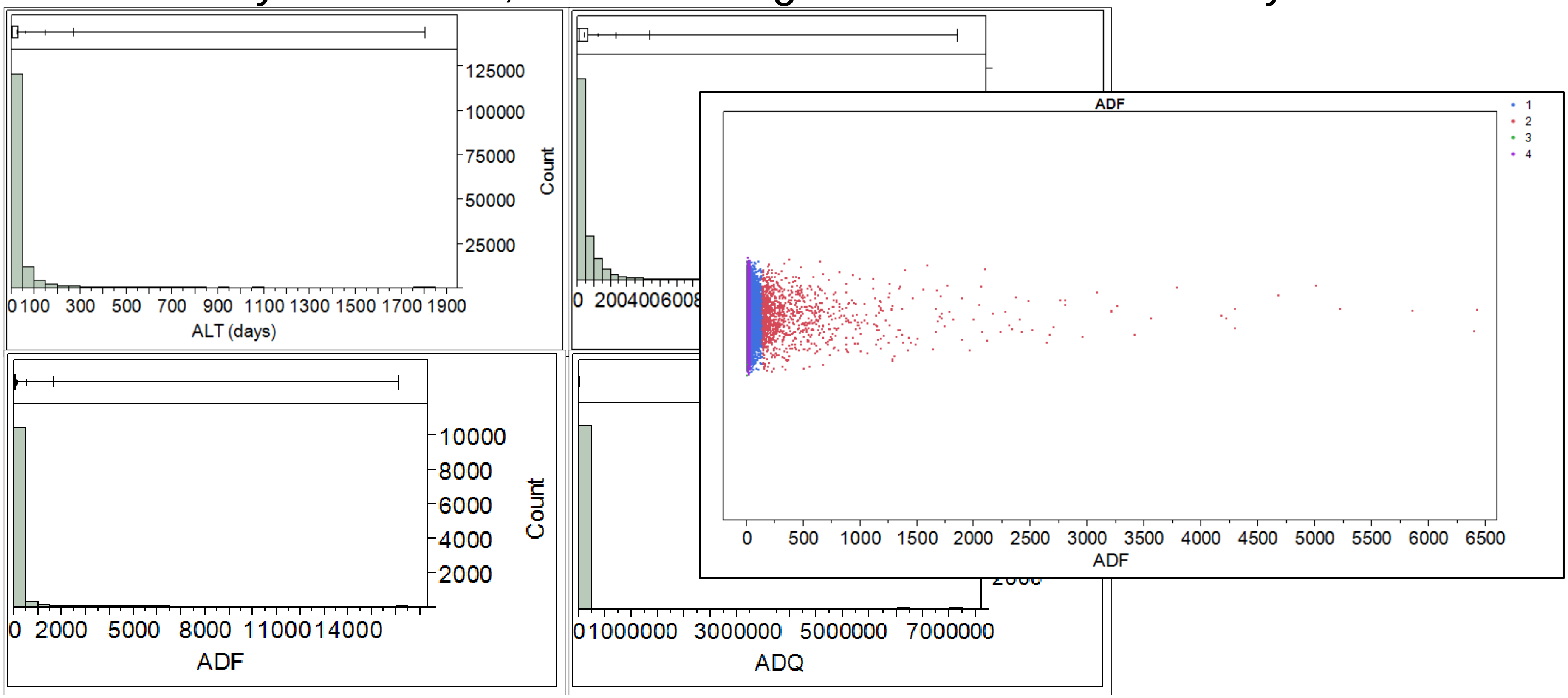
Data Exploration - Statistics

Stat	Admin. Lead Time	Prod. Lead Time	Annual Demand	Annual Demand Freq	Admin. Lead Time CoV	Prod. Lead Time CoV	Demand Value	Annual Demand Value	Back Orders	Materiel Avail.
Unit	Days	Days	Quantity/ year	Frequency /year	CoV	CoV	Dollars	Dollars/year	Quantity	Proportion
Median	6	11	85	22	1	2	$29,810	$8,578	0	1
Mean	23	44	2,170	81	2	4	$246,520	$73,628	1	.88
Std Dev	44	76	91,797	304	3	10	$1,634,199	$570,643	11	.28
Min	0	0	1	1	0	0	$0	$0	0	0
Max	1,806	2,300	7,156,000	16,104	110	519	$130,447,287	$47,533,104	454	1
CoV	1.93	1.72	42.3	3.75	-	-	6.63	7.75	11	0.32
# Obs	137,897	200,572	10,672	10,672	138,456	200,572	266,198	10,672	22,280	22,280

- Scoped the data down to the Land Supply Chain NIINs

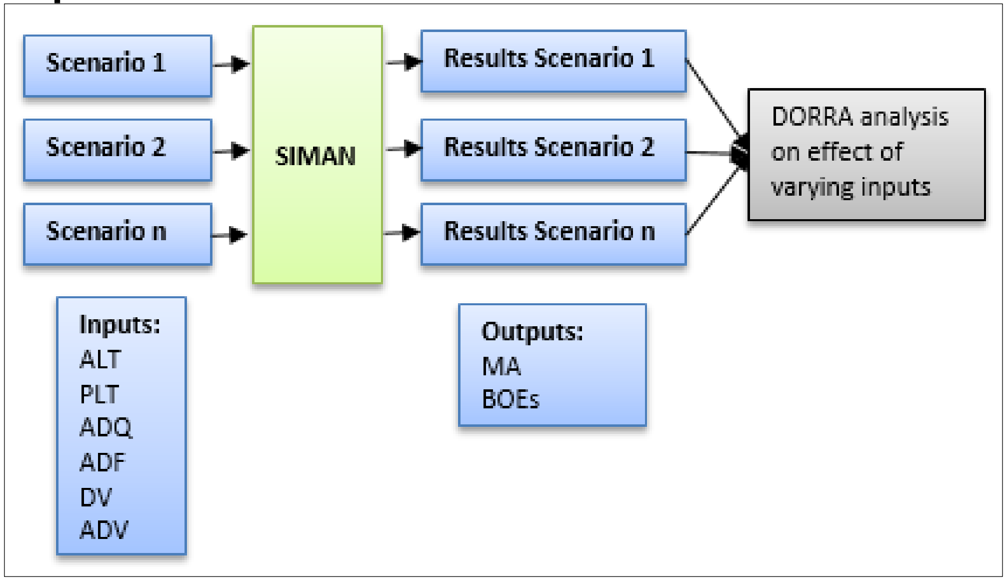
Cluster Analysis

- Analyzed data with K-means to identify predictive attributes and group similar behaving NIINs
- Due to unsatisfactory results in clustering because of high skew and variability in the data, the clustering was not used to classify the data



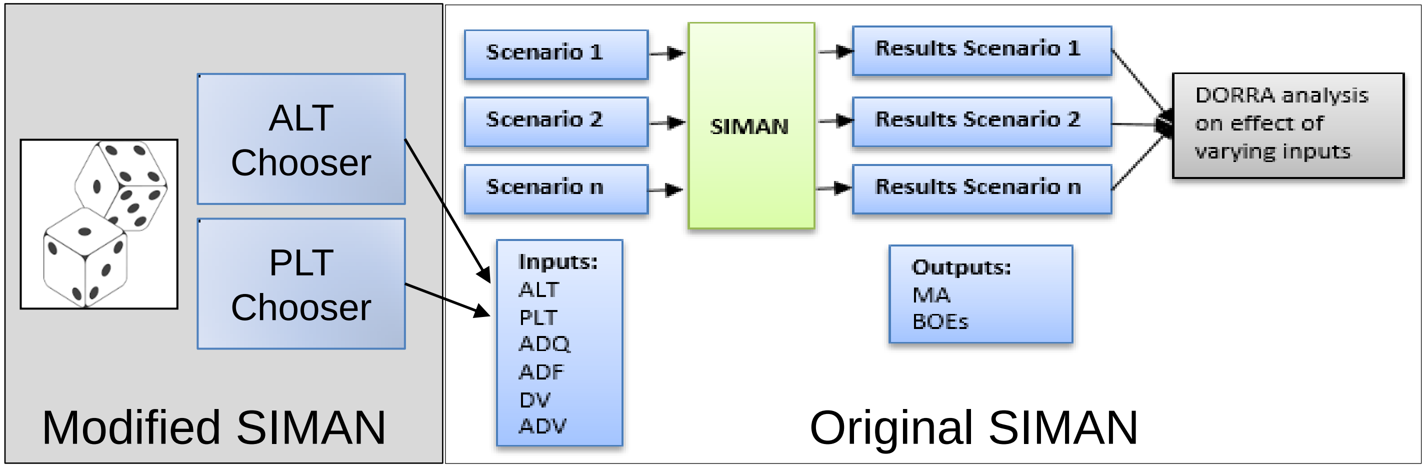
Current Model - Discrete Simulation Model

- System of Integrated Metrics Analysis (SIMAN) currently used to assess the effect of policy changes
- Discrete variables are inputted into SIMAN, SIMAN determines the resulting output variables, and results are analyzed to understand effects of inputs
- SIMAN data process:



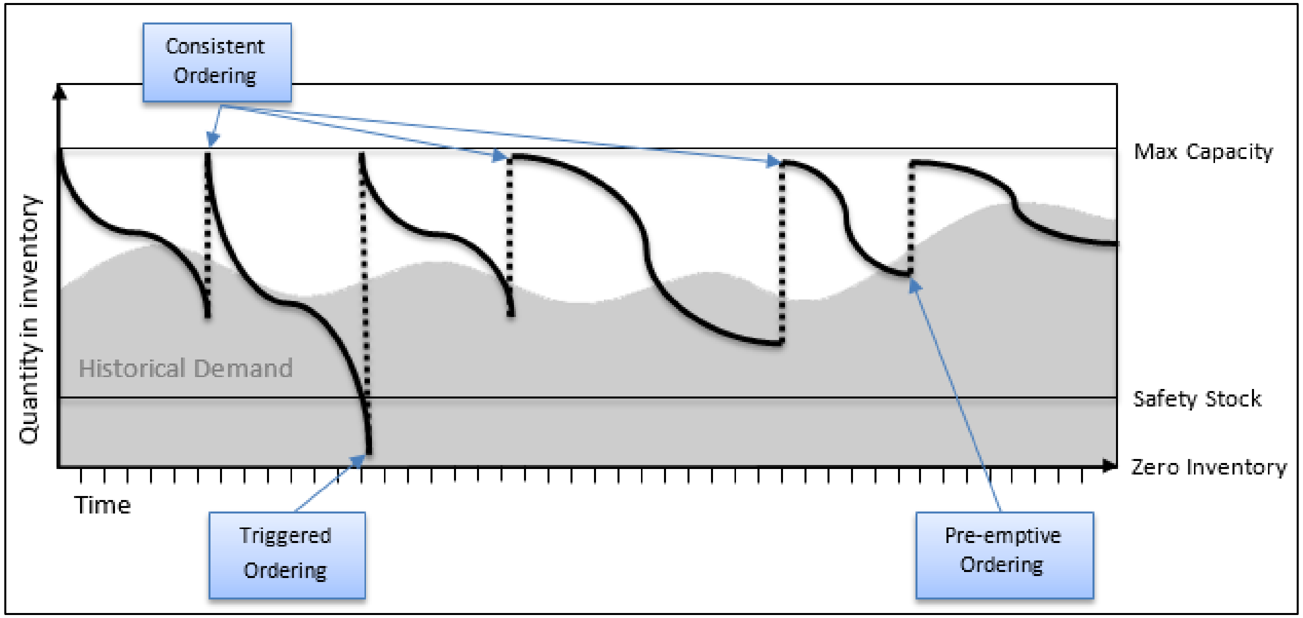
New Model – Stochastic Simulation Model

- SIMAN was modified to incorporate stochastic input for lead time variables
- Provides more accurate results on Materiel Availability and Back Orders Established
- *New* SIMAN data process:



Model – Optimization Model Overview

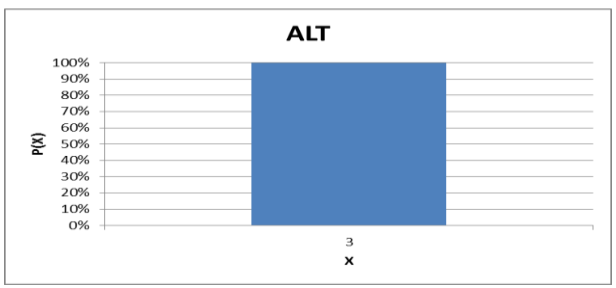
- Inventory optimization using stochastic simulation
- Incorporates stochastic inputs, historical demand, and differing ordering methods to determine optimal inventory policies
- Notional ordering methods diagram:



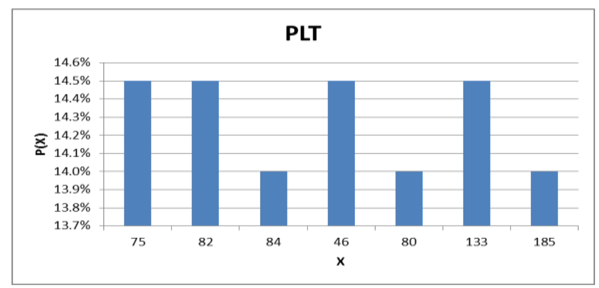
- Assumes orders occur daily and initial Inventory is at a maximum
- Minimizes excess inventory stock while meeting demand

Model – Stochastic Inputs

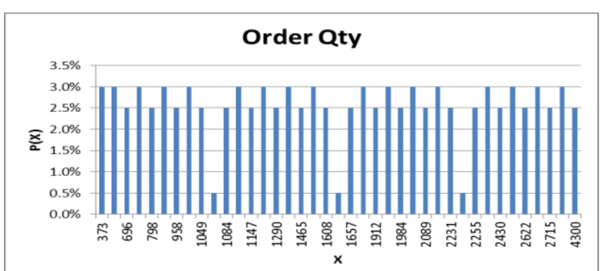
- Probability mass functions (PMFs) and Cumulative distribution functions (CDFs) determined for:
  - Administrative Lead Time, Production Lead Time, Demand Quantity, and Demand Frequency
- PMF examples of a NIIN for a component used on tanks:



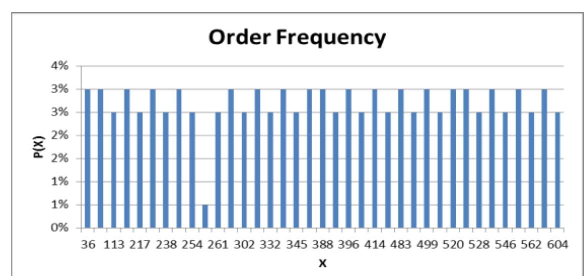
Admin Lead Time



Prod Lead Time



Order Quantity



Order Frequency

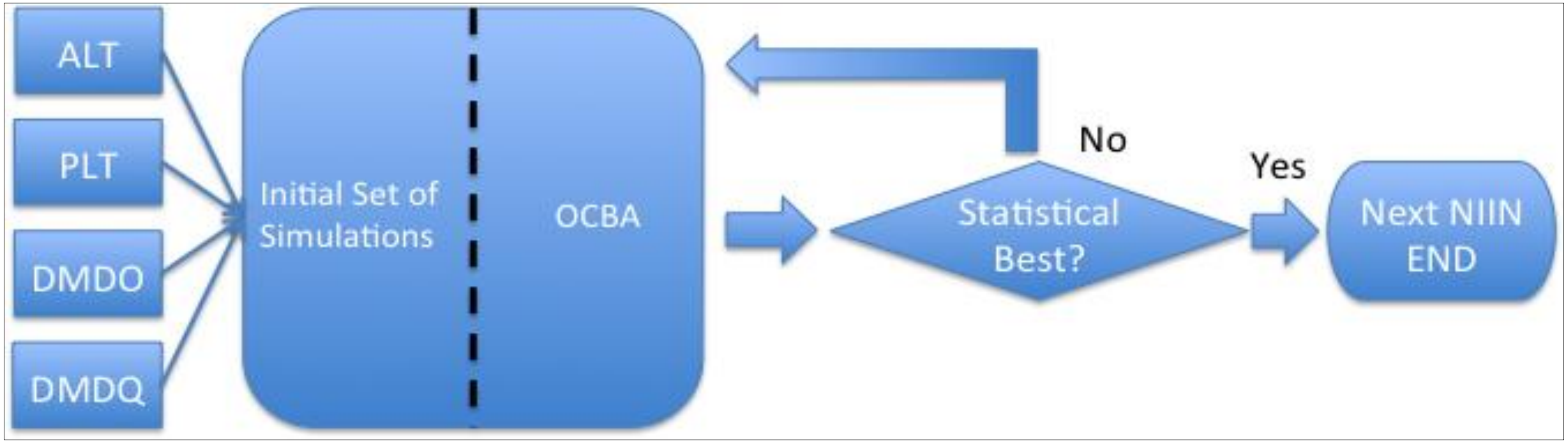
Ordering Policy Tools

- **Consistent ordering** – Easiest to identify when Demand Variance is minimal
  - A constant amount is chosen to be ordered at a given interval
  - Simplest for the customer to implement, least powerful
- **Triggered ordering (s,S)** – Best to use when Demand Variance is moderate
  - Dropping below a threshold causes an order to be generated which would return inventory to a set holding level
  - Harder to implement in practice, more powerful
- **Pre-emptive ordering** – Best to use when Administrative Lead Time and Production Lead Time have high variance
  - Creates an order at a pre-appointed time to counteract an historical surge in demand
  - Requires more input by the customer up front

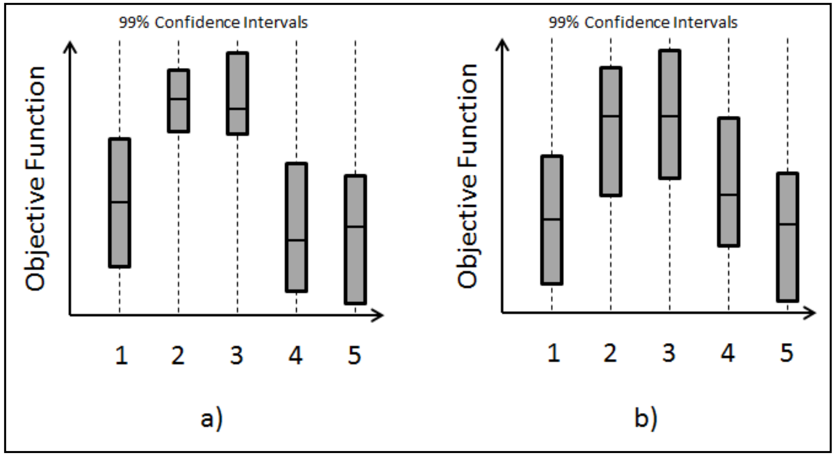
- The model uses OCBA (Optimal Computing Budget Allocation) to determine which combination of settings within the user's constraints returns the best result.

Model – Optimization using Simulation

- Optimal Computing Budget Allocation (OCBA) process:

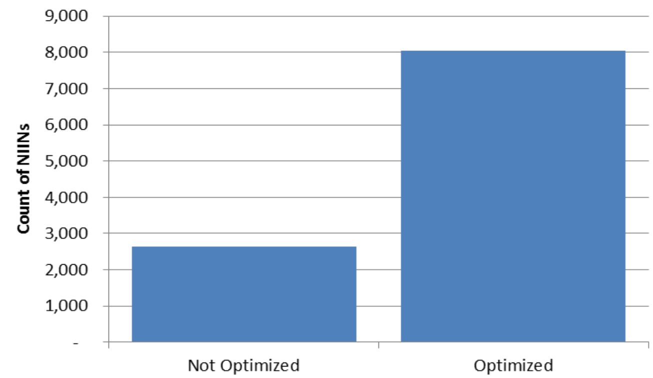


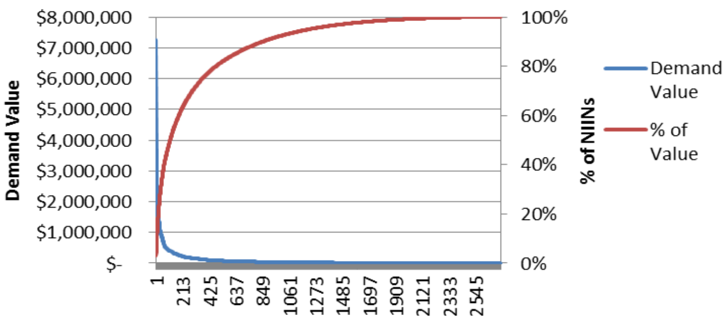
- Notional solutions:
  - 100 Simulations were required for each policy in the initial set.
  - Up to 10,000 additional replications can be assigned sequentially to determine the policy which minimizes holding cost
  - Total run-time for all 12,000 NIINs was around 40 hours



Model – Optimization Results

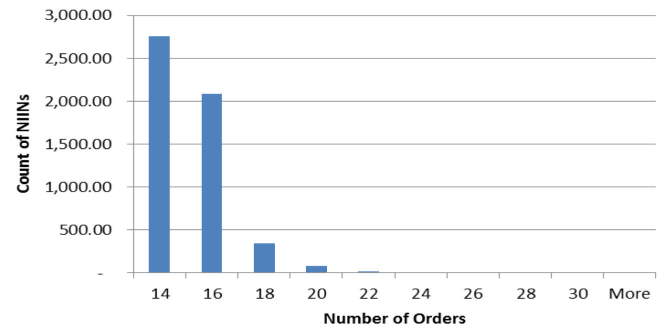
75% of the NIINs met DLA threshold of 90% Materiel Availability





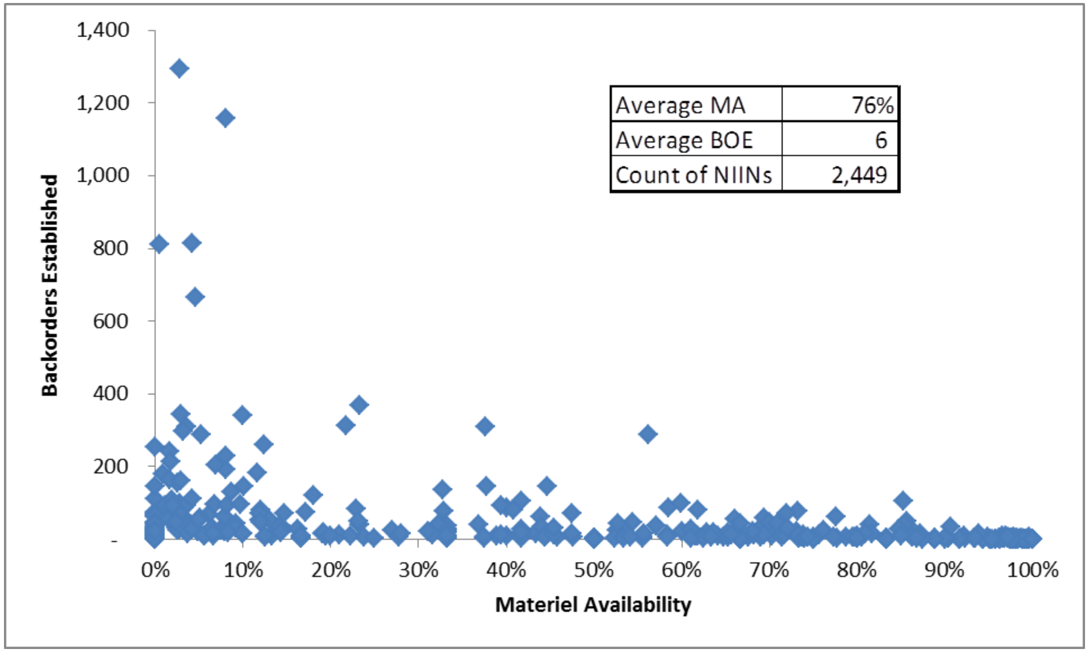
Optimal policies for ~2,700 NIINs did not require consistent ordering at all. This dramatically reduces the required number of orders.

Order frequency was determined for over 8K NIINs to achieve this a level of Materiel Availability

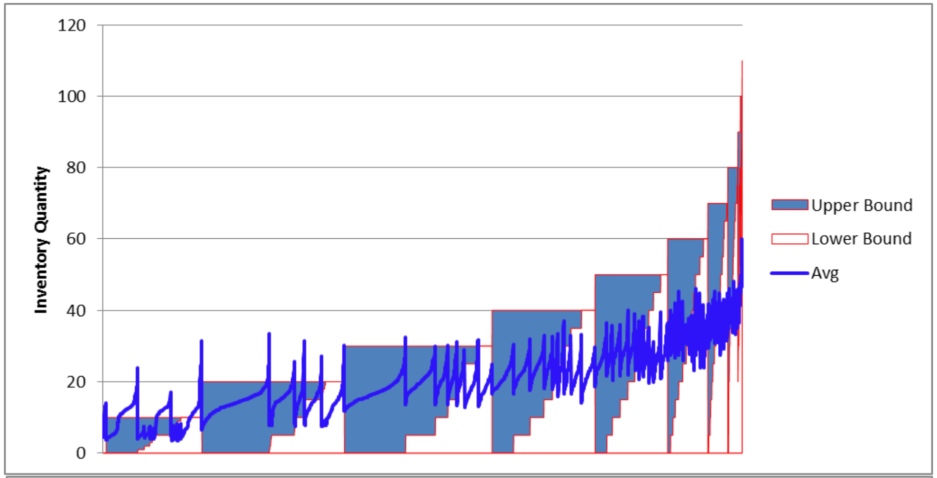


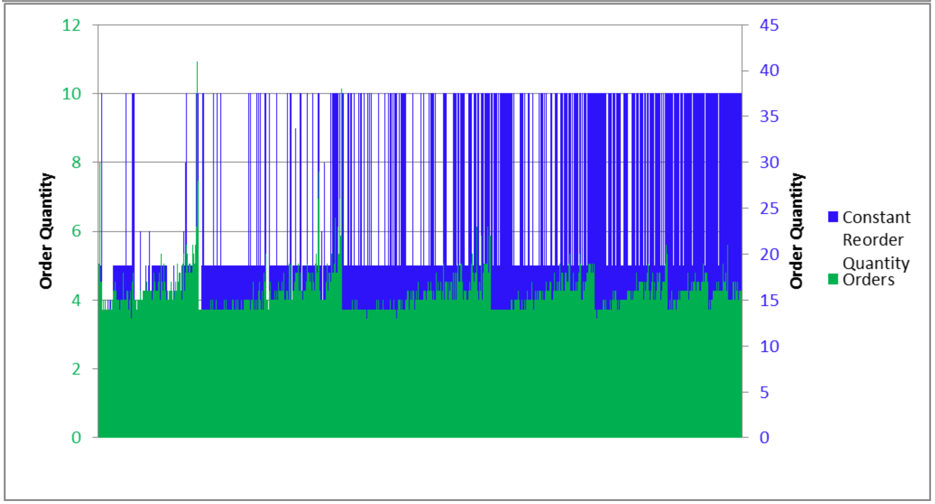
Model – Unsolved Items

- Current on average Materiel Availability is 76% for NIINs that could not be optimized
- Recommend further investigation into alternative management policies for these NIINs.
  - Consider increasing the human-in-the-loop management style in order to maintain Materiel Availability



Model – Optimization Results





- The safety stock level approaches the triggered reorder point as the consistent order quantity decreases
- As the order quantity grows the average inventory level and holding cost increases
- The order frequency is not a valid indicator of what inventory levels should be

Model – Order clusters

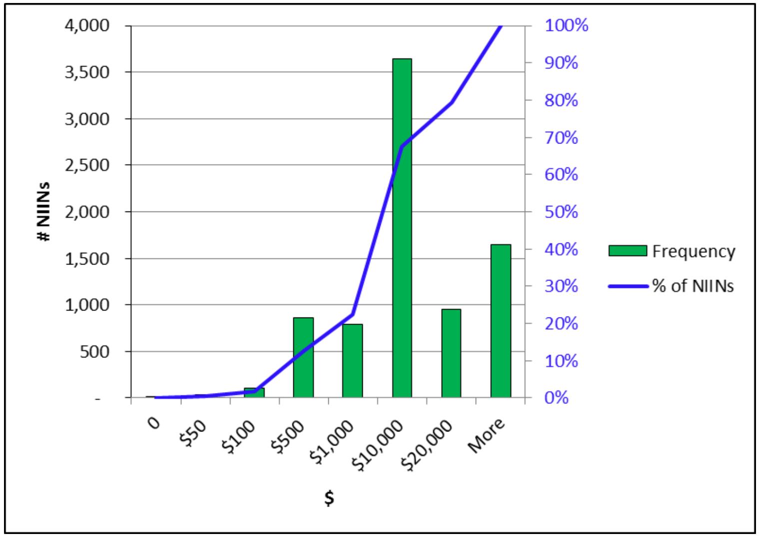
Cluster Size	
Cluster #	# of obs
1	2583
2	2630
3	5459
Cluster centers	
Cluster #	# of orders
1	3.39
2	0
3	14.53
Total # of Orders: 88,080	

- Cluster 1 (Blue): ranges from 1 to 3 average orders, easy to maintain MA
- Cluster 2 (Red): 0 orders, does not maintain MA
- Cluster 3 (Green): ranges from 3 to 105 orders, requires large orders to maintain MA

Model – Cost Trends

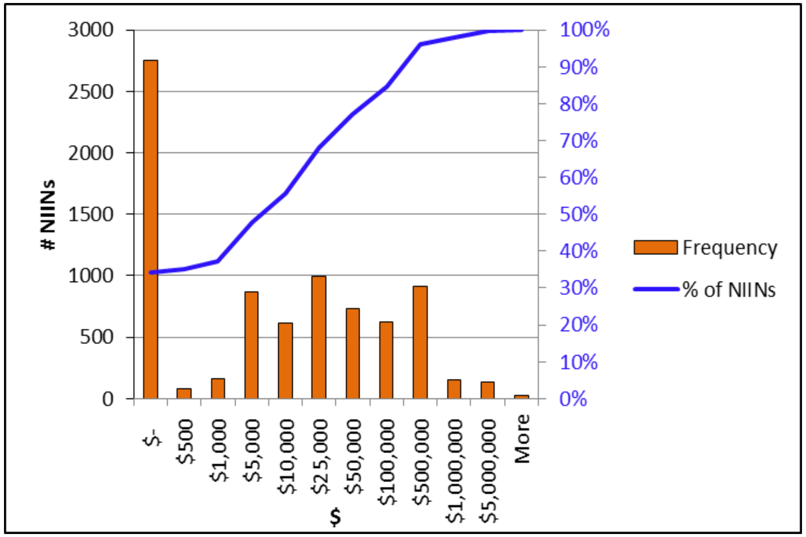
Holding Cost

- Total average Holding cost for optimized NIINs: $241M
- Majority cost less than $20K annually



Ordering Cost

- 78K total orders, or 214 per day
- Total Ordering Cost for optimized NIINs: $1.004B
- Which is 39% less, or $1.004B to $1.635B, than average Value from FY12-FY14



Recommendations

- Further investigate alternative management policies for the 25% of inventory that cannot meet Material Availability
- To improve scalability of modeling efforts identify:
  - Unique ways to conduct searches and cut suboptimal result sets
  - Identify ways to reduce the size and number of modeled items at one time through Network Component Decomposition for items that are frequently ordered together
- Improve speed of current inventory models by
  - converting SIMAN from SAS to Java or R
  - eliminating processes that take a computationally long time to execute (e.g. appending or merging tables in a data step rather than an append statement or SQL join statement)
- Increase the total trade space searched, incorporate a new search algorithm to improve search times
- Add an additional constraint to cap the number of orders allowed.

Team

- Matthew Mahoney
  - Operations Research Master's Student
  - B.S. in Mechanical Engineering VA Tech.
  - Operations Research Analyst with SPA inc.
- Derek Eichin
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  - B.S. in Mathematics from VCU
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