The Puzzles and challenges of Internet Logistics

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Amazon.com

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Today's Talk

- The Amazon.com Platform
- The Amazon Network Design and Model
- Network Optimization and Modeling
- Inventory Modeling and Optimization
- Transportation Management
- Operational Excellence
- Defining Success

Amazon.com Platform

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Amazon.com - Our Approach

1. Invest big in a big, global market
2. Globally drive for scale, growth
3. Reap the benefits of scale

   **Better decisions drive higher capital efficiency*

4. Repeat

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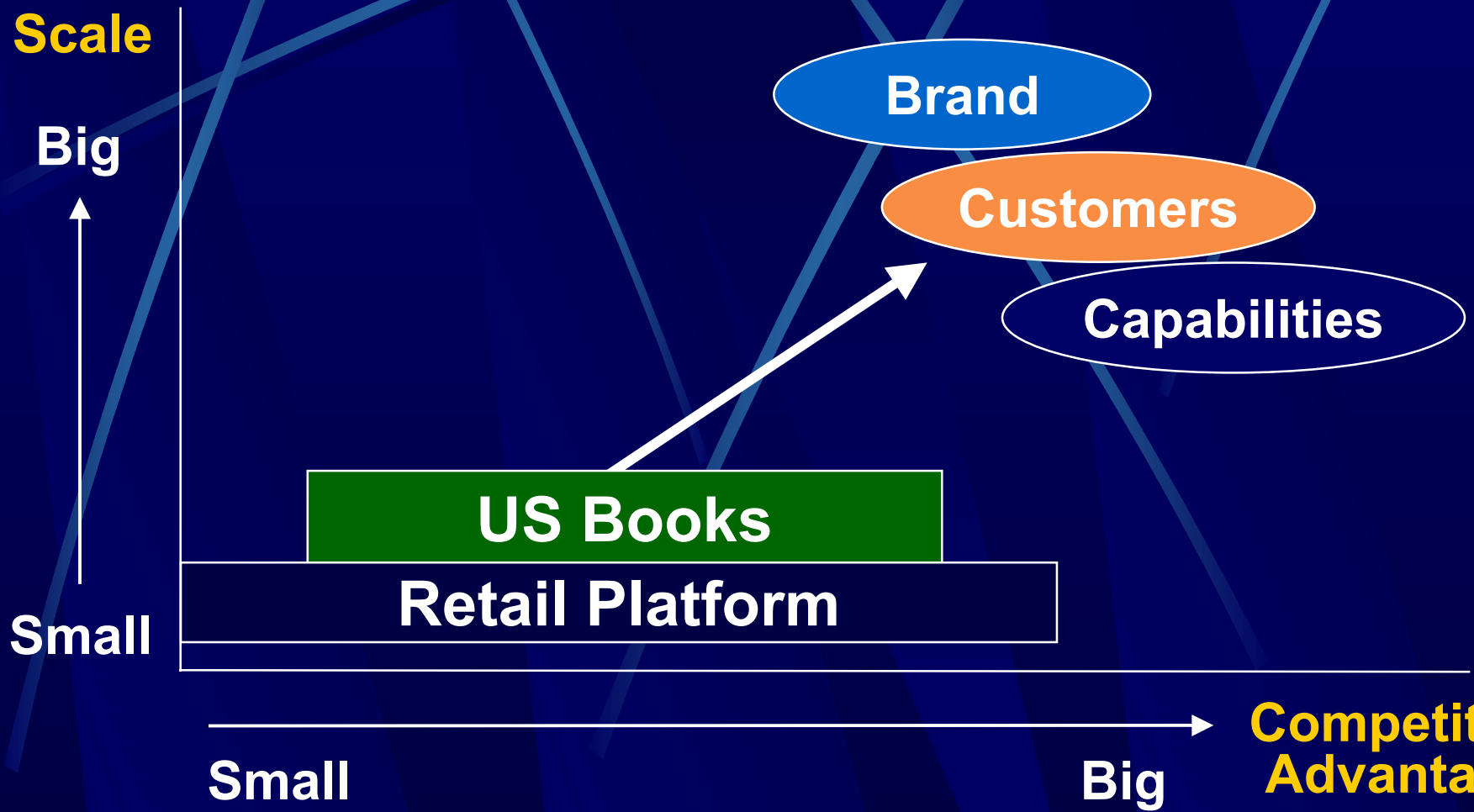
Building The Platform(1995 - 98)



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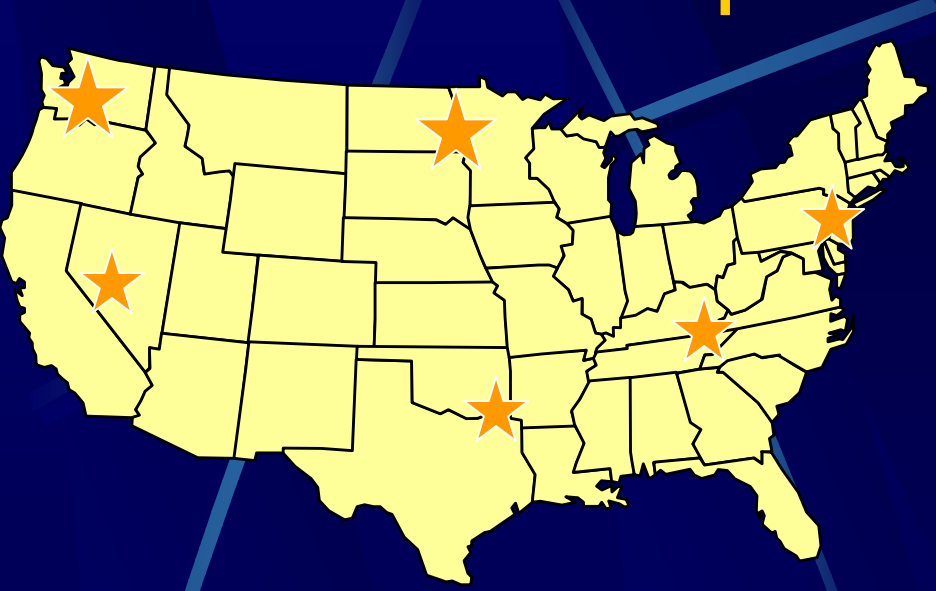
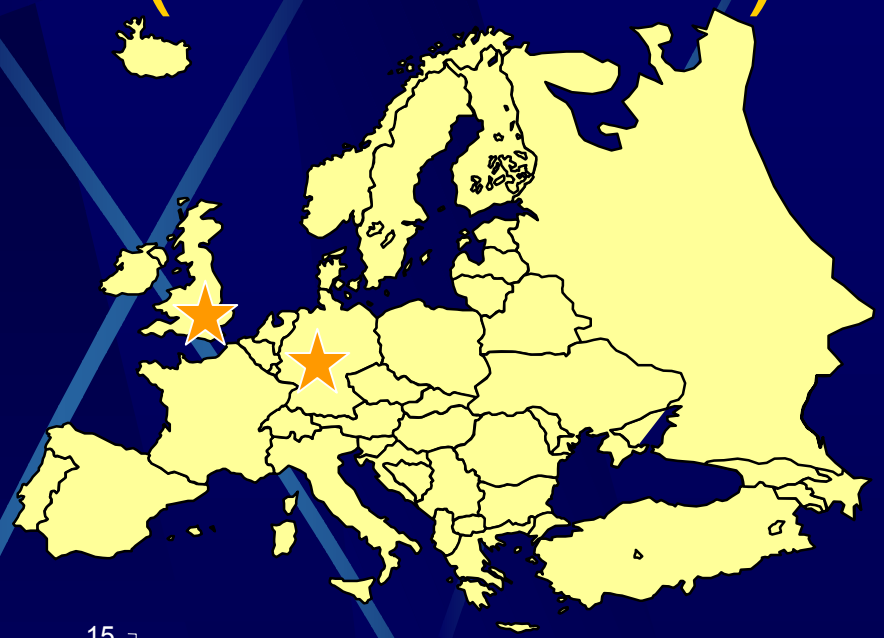
Platform Expansion (1998 - 2000)





US

UK

DE

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Amazon.com Platform

- Growing customer base
- Technology
- Optimized distribution advantage
- Customer service focus
- E-commerce expertise
- Investment in intelligence
- Brand

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Amazon.com Network Design and Model

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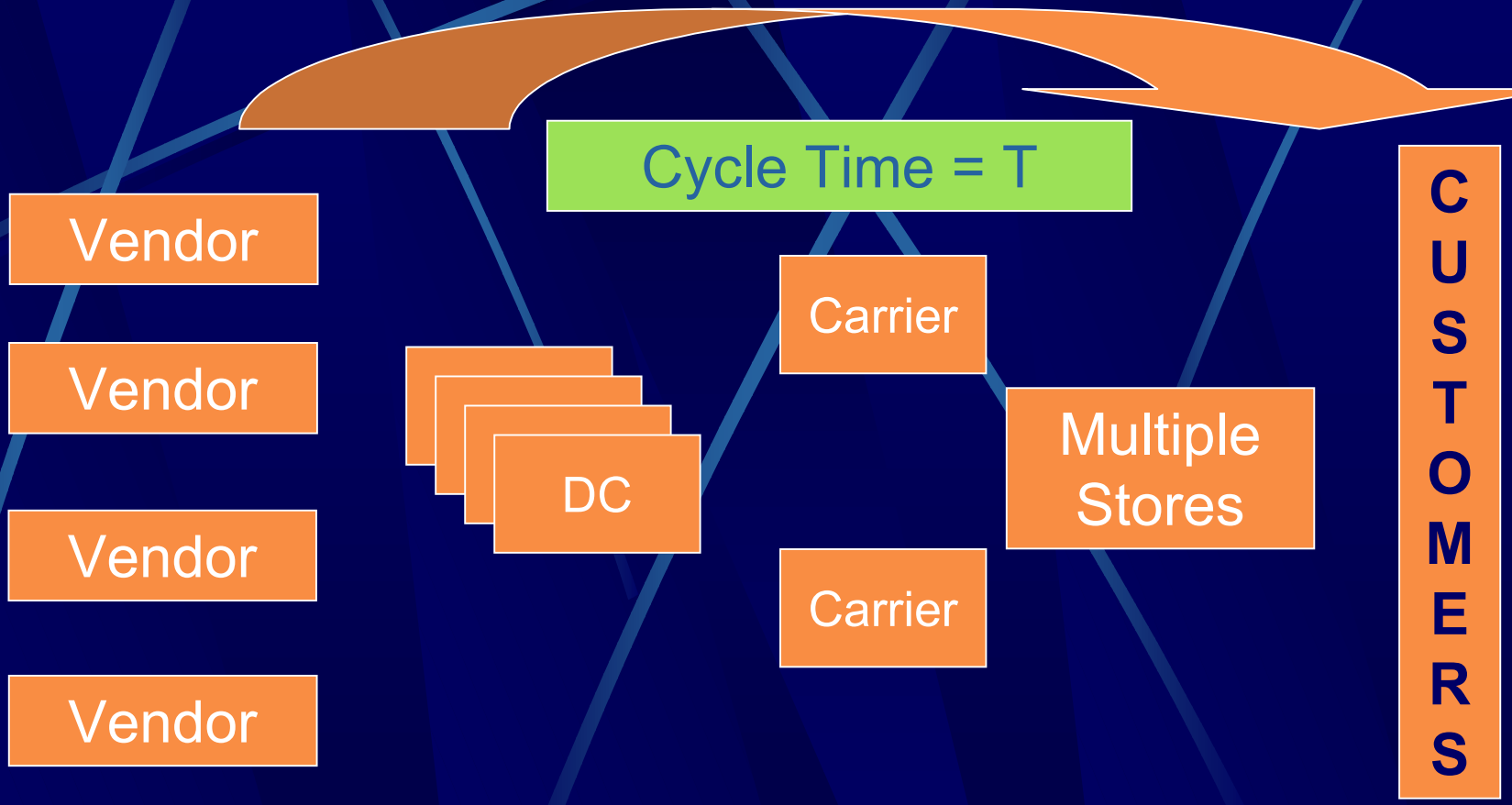
Traditional Model



Physical Store Chain Dependency = Increased Cycle Time

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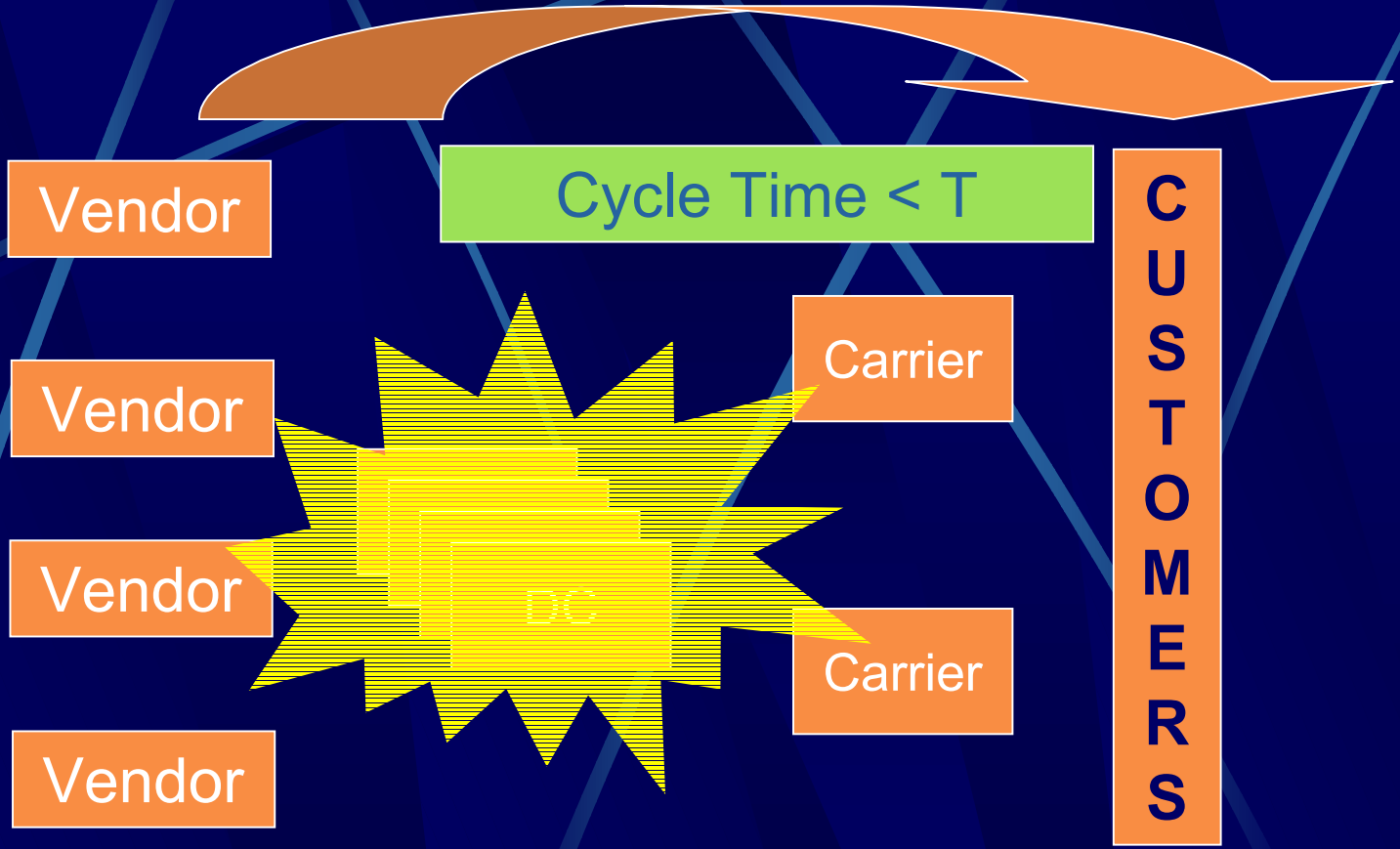
Amazon Model



Reduced Cycle Time = Reduced Inventory

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Consumers' View

Global Consumers:

- Want quick delivery
- We're trying to drive them to want infinite selection
- Pay only for perceived value add

E-commerce challenges are a function of customer preferences

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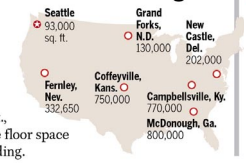
The New Fulfillment System

FROM YOUR MOUSE TO YOUR HOUSE

What goes on behind the scenes when you place an order at Amazon.com

1 You order three items, and a computer in Seattle takes charge

A computer assigns your order—a book, a game and a digital camera—to one of Amazon's seven distribution centers, five of which it opened this year. With 3 million sq. ft., Amazon has 1.5 times the floor space of the Empire State Building.



2 In suburban Atlanta, three red lights go on

Your order is transmitted to the closest facility that has the products. Amazon's newest, in McDonough, Ga., opened in October and stocks more than a million items. Rows of red lights show which products are ordered. Workers move from bulb to bulb, retrieving an item from the shelf above and pressing a button that resets the light. Computers determine which workers go where.

3 Your items are put into crates on moving belts

Each item goes into a large green crate that contains many customers' orders. When full, the crates ride a series of conveyor belts that winds more than 10 miles through the plant at a constant speed of 2.9 ft. per sec. The bar code on each item is scanned 15 times, by machines and by many of the 600 full-time workers, all of whom get Amazon stock options.

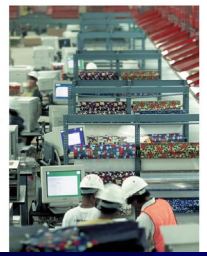
4 All three items converge in a chute, and then inside a box

All of the crates arrive at a central point where bar codes are matched with order numbers to determine who gets what. Your three items end up in a 3-ft.-wide chute—one of several thousand—and are placed into a cardboard box with a new bar code that identifies your order.

PHOTOGRAPHS FOR TIME BY DAVID BURNETT—CONTACT

5 Any gifts you've chosen are wrapped by hand

Amazon trains an élite group of gift wrappers to "make it look like Mom's." Each worker processes 30 packages an hour (those who fail are reassigned to other jobs). For its busiest season yet, Amazon's warehouses are stocked with 4.4 million yards of ribbon and 7.8 million sq. ft. of wrapping paper—which if laid flat would more than cover Disneyland.



6 The box is packed, taped, weighed and labeled before leaving the warehouse in a truck

The McDonough plant was designed to ship as many as 200,000 pieces a day. About 60% of orders are shipped via the U.S. Postal Service; nearly everything else goes through United Parcel Service. Both have large facilities within 10 miles of the warehouse. Products that are unusually big or heavy (150 lbs. or more) require special delivery.

7 Your order arrives at your doorstep

Voila! One to seven days later, yet another of Amazon's 13 million customers has been served.

—By Joe Zeff

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Network Optimization and Modeling

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Network Optimization System - Methodology and Structure

- Minimize
  - Outbound shipping cost
  - Labor costs
- Key Constraints
  - Satisfy customer demand
  - Outbound shipping/processing capacity
  - Labor capacity (minimum and maximum)
  - Storage capacity
  - DC processing capabilities
  - Inventory, long zone, and splits targets

Objectives

- Design network ……
  - Define number and location of Fulfillment Centers (FC)
  - Define velocity categories by product line
  - Allocate product categories to FC's
- in order to minimize ……
  - Transportation Costs
  - Capital Expenditures
  - Operating Expenses
- and maximize
  - The probability of a successful ramp to Holiday volumes

Intelligently model and optimize FC network for Inbound/outbound processing and transportation costs

Model Magnitude and Input Data

Data

- Shipping rate, Zone tables by FC
- Inventory Targets from Retail/SC
- Demand Forecast by product by month
- Demand Distribution
  - product by zip3 and velocity by month
- Product Data
  - sort type, velocity, avg. cube, avg. weight, receive type, units per pack, units per tote, gift wrap, vendor compliance (assortments)
- Storage space by bin type by FC
- Order profile
  - Units per order, product mix
  - Probabilistic splits
- Equipment capacity, labor constraint
- Productivity

Model Size

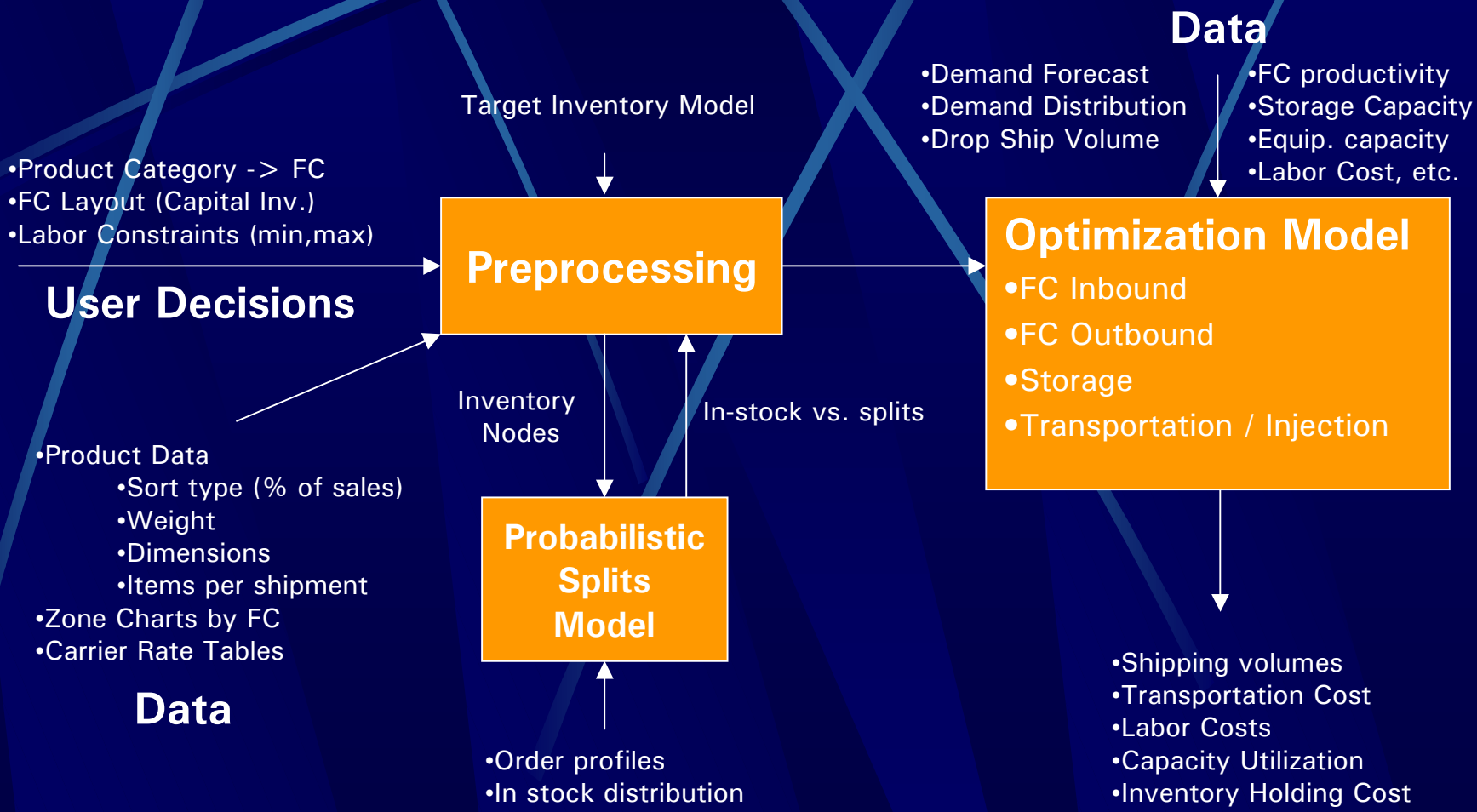
- Outbound Shipping and Injection

  Problem Statistics:
  - 516,888 constraints
  - 1,488,898 variables
  - 8,209,586 non-zero elements

```
Optimal solution found
XPRESS-MP 12.13: Optimal solution found
Objective 3225327.561
59262 Simplex iterations
Solution:

Shipping cost for Apr-01       3214938.70
          3.215 MM
```

Solution Methodology



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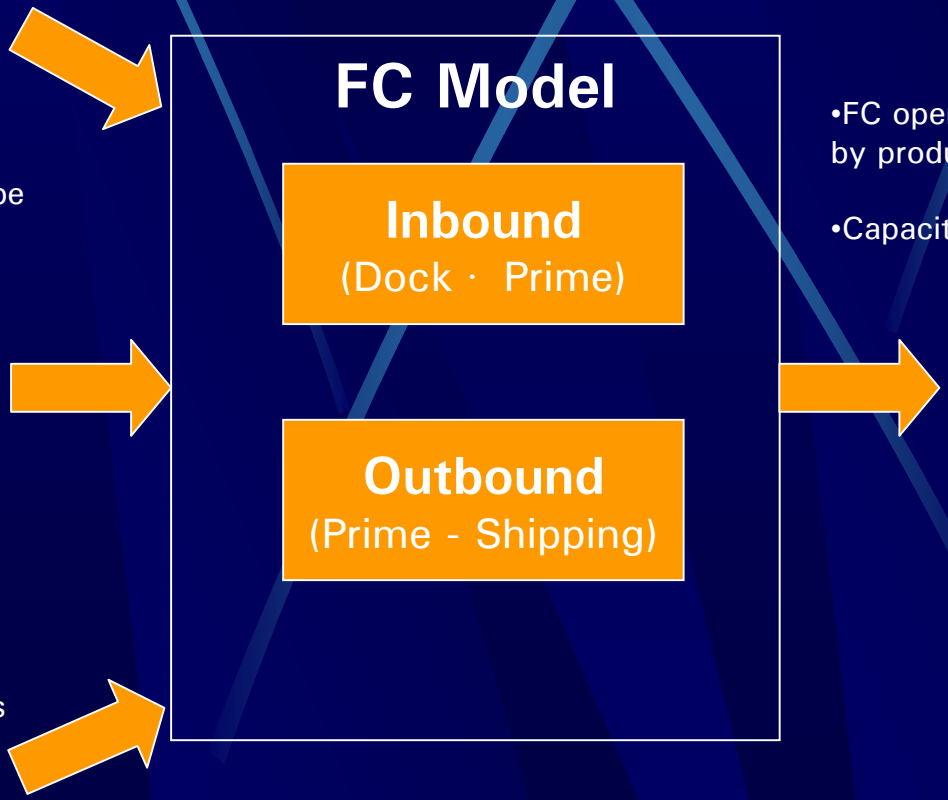
FC Model

- Vendor compliance (assortments, floor load, etc.)
- Avg. pack size by product line
- Units by receive type & ship type
- Productivities by dc and station
- Fully burdened wage rate
- FC layout
- Problem solving
- Special processing requirements
- Avg. pack units per tote



- FC operating expenses by product line & path
- Capacity constraints

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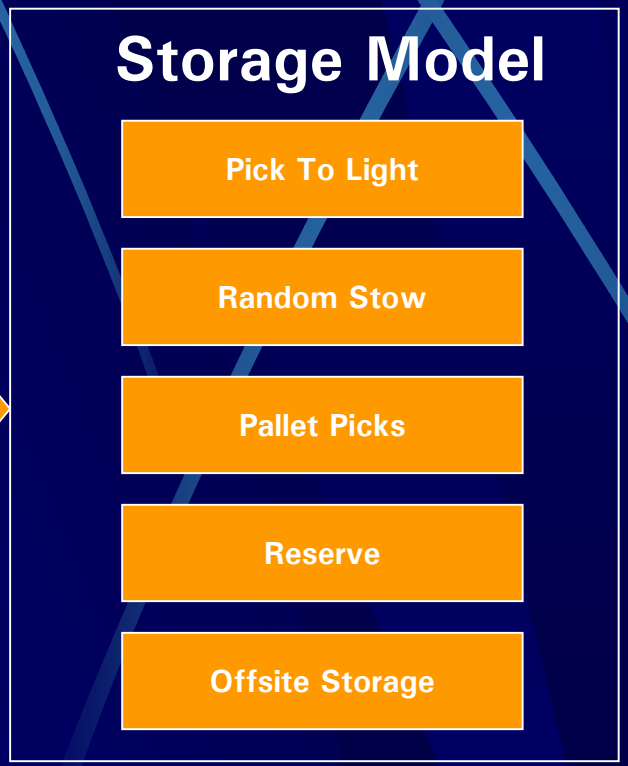
Storage Model

- Product line shipping forecast
- Inventory turn targets by product line
- Velocity & profiling requirements
- Weight & Size characteristics
- Interchangeability of storage types



- Optimal storage profile by FC
- Storage capacity utilization
- Storage costs by product line
- Offsite storage requirements

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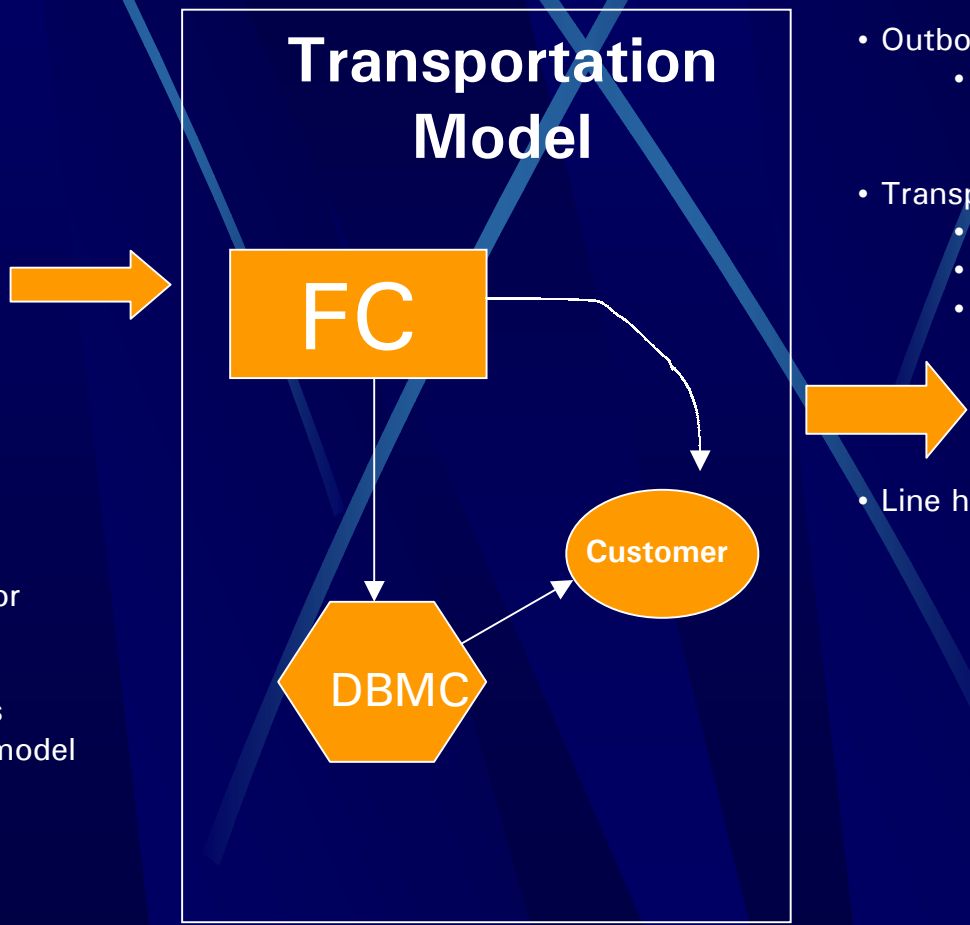
Transportation Model

- Product line shipping forecast
- Product Data
  - Sort type (% of sales)
  - Weight
  - Dimensions
- Order Data
  - Items per Order
  - % Single Item Orders
- Zone Charts by FC
- Carrier Rate Tables
- DBMC distances and locations
  - Zips reached by DBMC
- Locations and processing costs for DDU sortation providers
- FC outbound capacity constraints
  - Integrated with outbound model



- Outbound shipping
  - Units by FC, product, sort type, and velocity
- Transportation cost
  - Projected shipments
  - Volumes from DC to Zip
  - Projected volume by carrier
- Line haul volumes for injection

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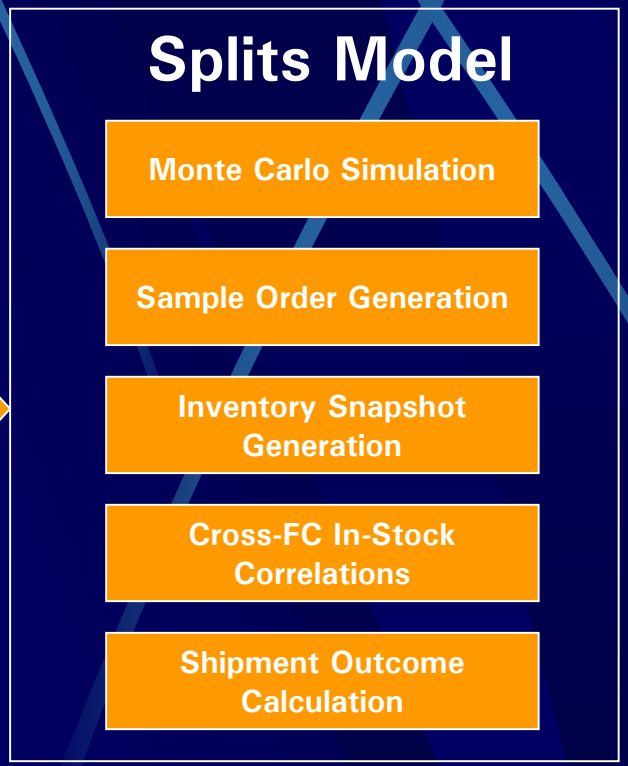
Probabilistic Splits Model

- Order profile
- FC structure
- Product velocity group aggregation
- In-stock percents by DC and network-wide



- Split order percentages
  - By order size
  - Aggregate
- Split shipment percentages
  - By order size
  - Aggregate

- „What if‰ scenarios
  - FC structure
  - Changes to in-stock %

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Inventory Modeling and Optimization

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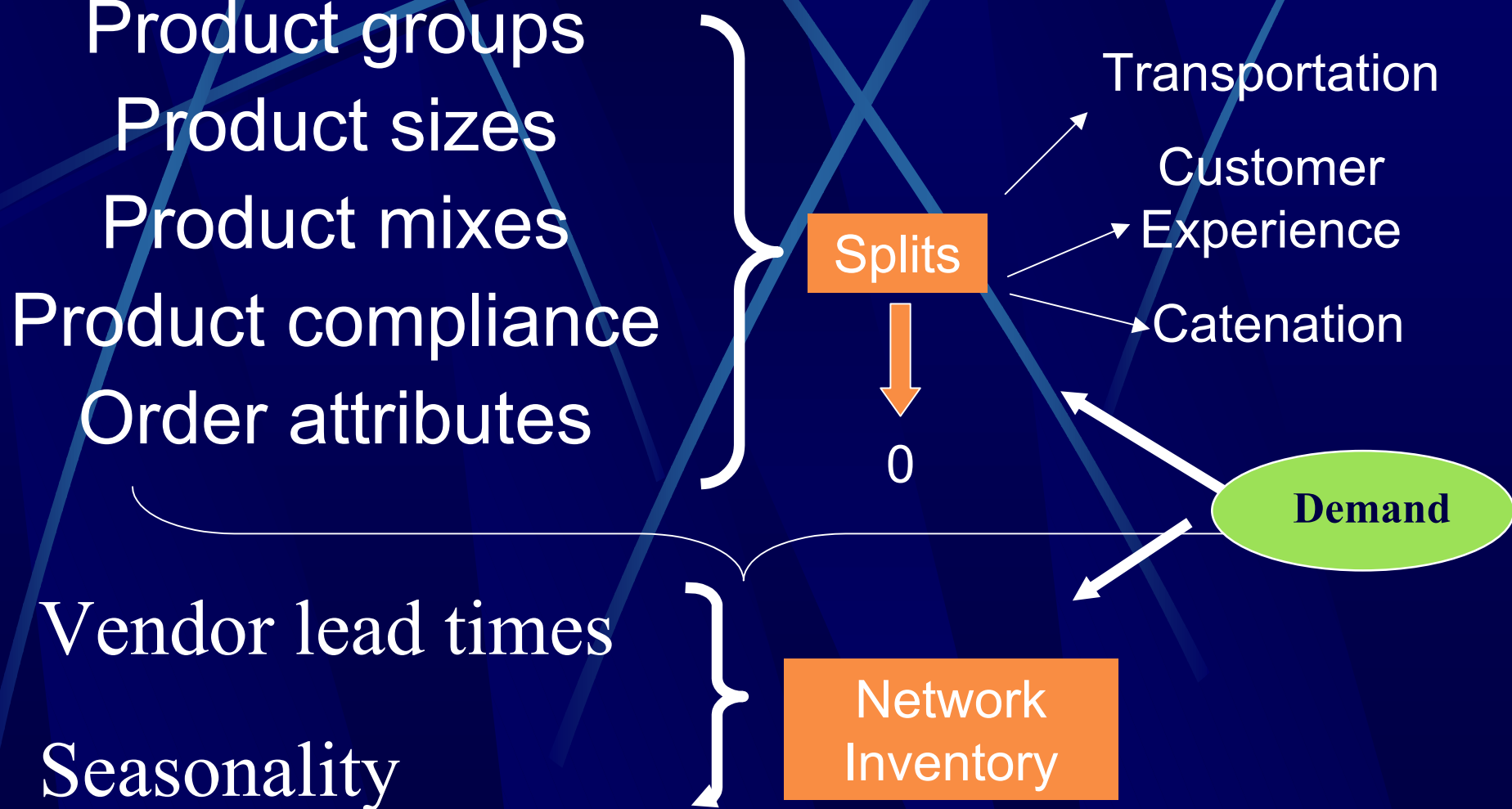
Inventory Drivers



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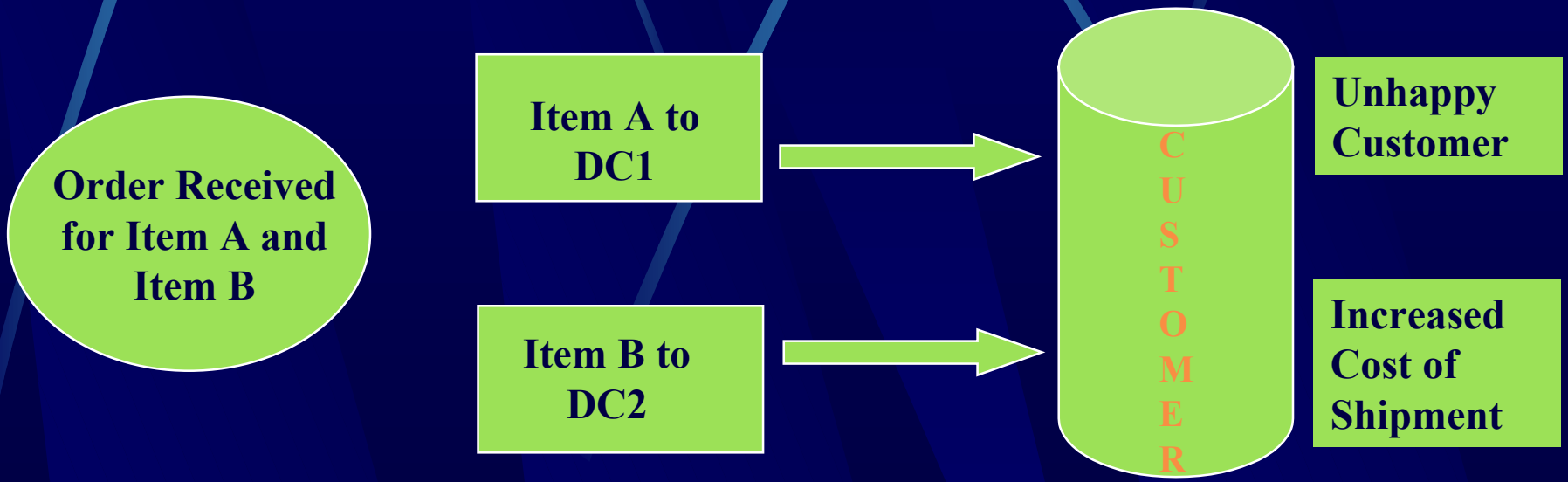
Split Shipments

An order that generates multiple shipments but only a single ship revenue



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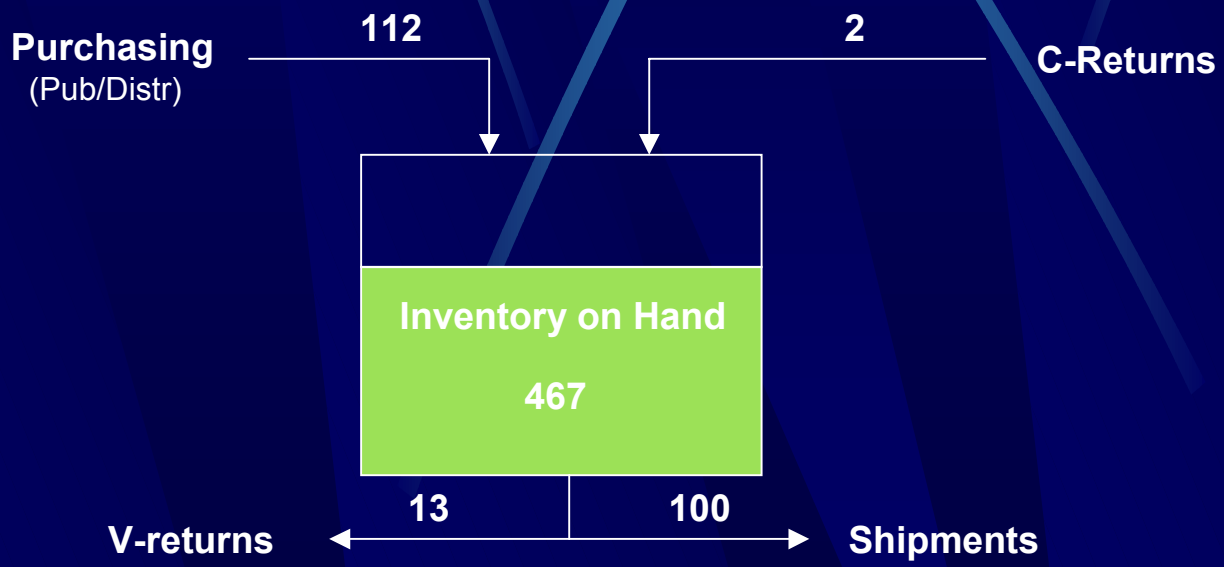
Current State

How do we control inventory?

Inbound: LA, LB, DS, SU, MU, and NYP

Outbound: Shipping (Pricing/Promos), Removals



Note: BMVD Inventory flow from 30-Apr S&OP (incl. Advantage)

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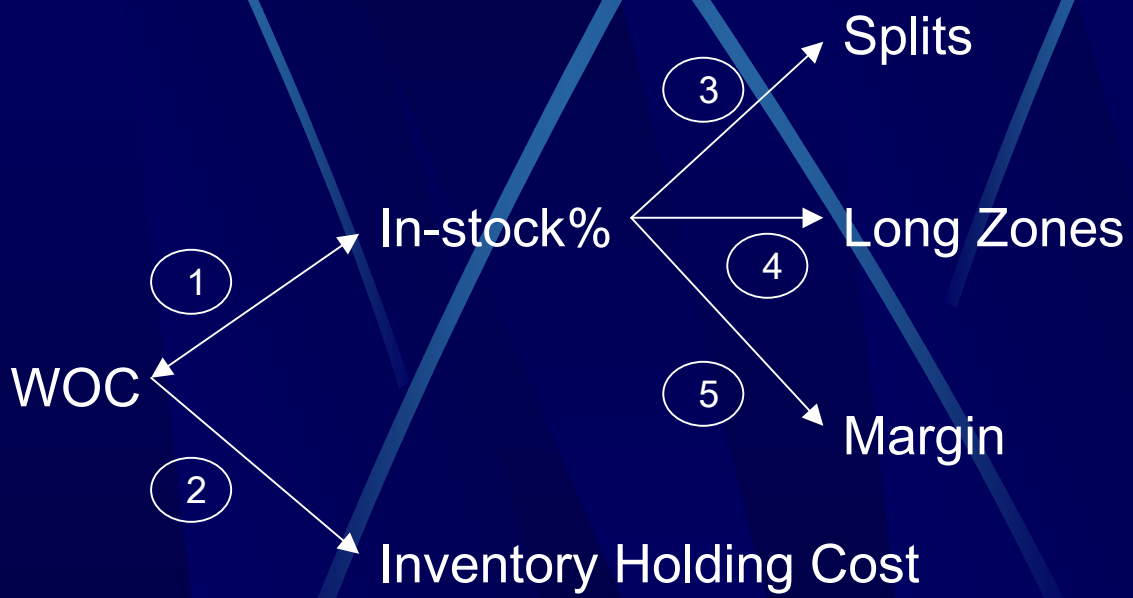
Economic Drivers

ECONOMIC COMPONENT		KEY COST DRIVERS
Transportation	Split Shipments	FC in-stock percents
	Long Zone Shipments	Inventory and in-stock balance between east and west coasts
Inventory Holding Cost		Weeks of Cover
Margin		Distributor versus Direct

Inventory Modeling Methodology

- Five Key Relationships Modeled



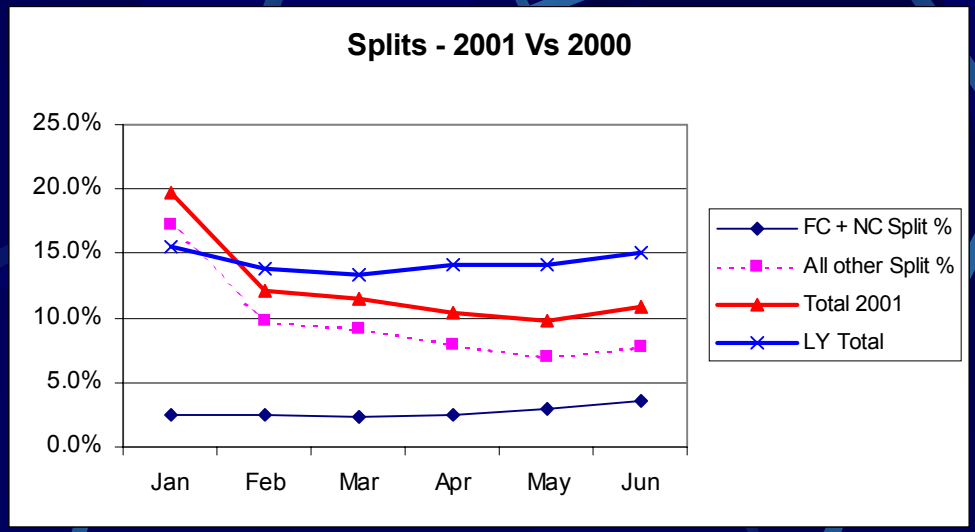
- Establish inventory policy based on economic drivers and control parameters for Fast, Medium, and Slow inventory

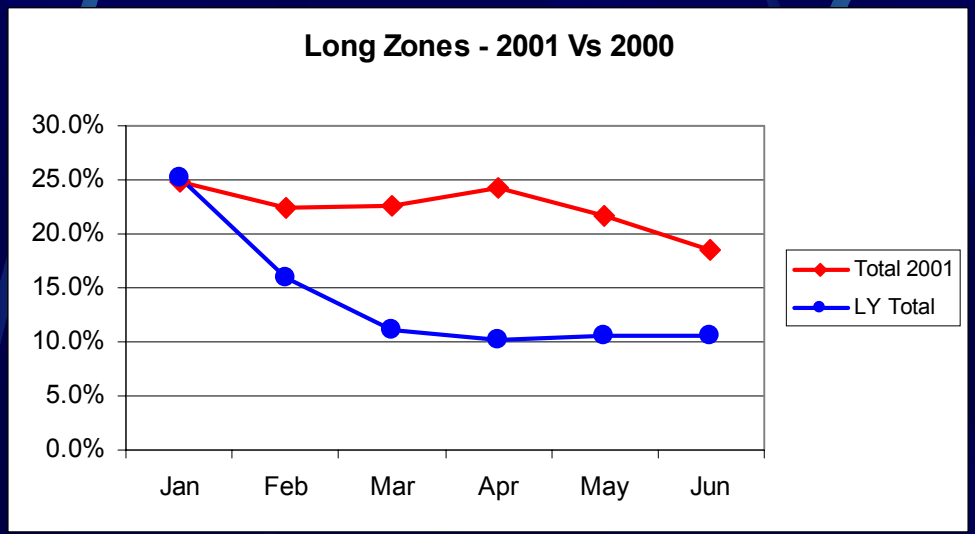
Fast BMVD Recommendations

Economic Analysis ($MM)

	Inventory Investment	Inventory Holding Cost	Splits Savings	Long Zones Savings	Margin Savings	Total Savings
Books	5.17	(1.71)	1.90	2.74	2.21	5.14
Music	0.93	(0.31)	0.20	0.47	0.18	0.54
Video	0.51	(0.17)	0.09	0.21	0.22	0.35
DVD	0.46	(0.15)	0.10	0.13	0.22	0.30
BMVD - overall	7.07	(2.34)	2.29	3.55	2.83	6.33

Splits and Long Zones





Splits
Driven by DC in-stock

Long Zones
Driven by balance of inventory and in-stock between east and west coast

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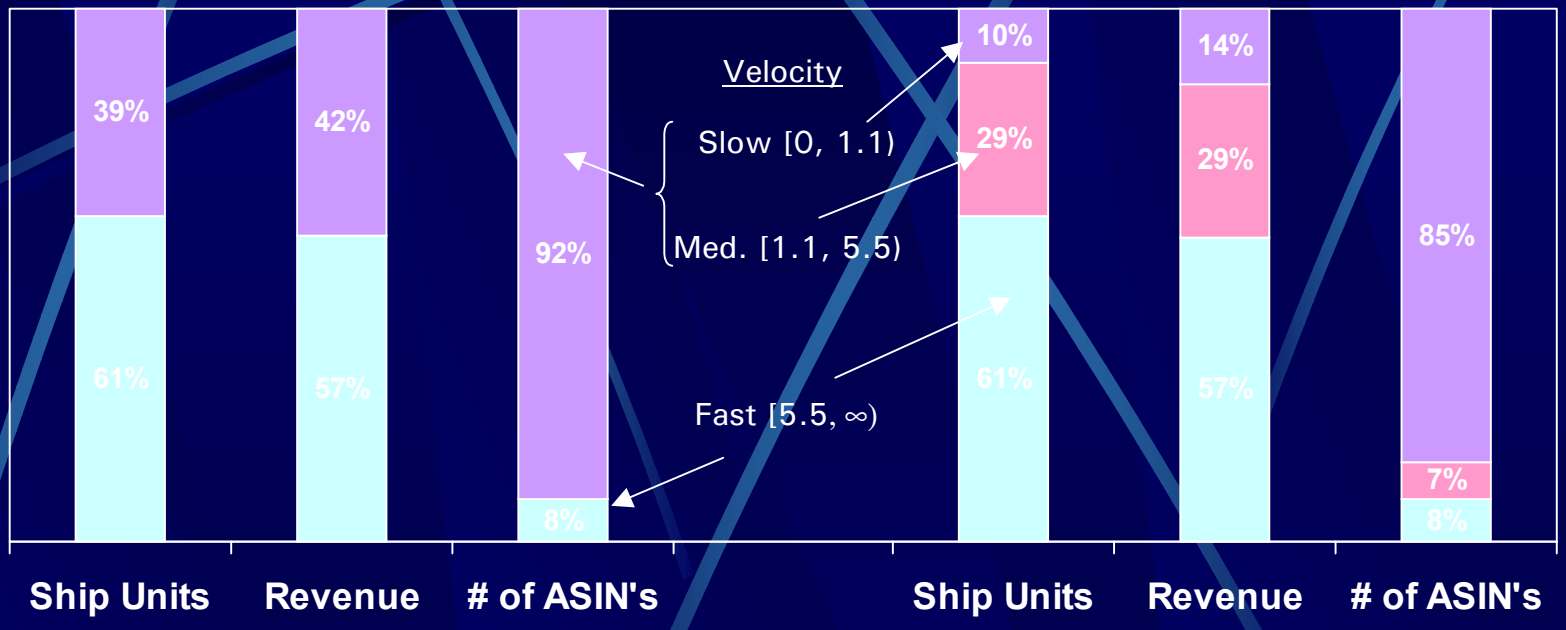
Comparison of Network Structure
BMVD



Old Structure 7/3

Slow		LEX1			SEA1	SDF1	
Medium							
Fast	ATL1	LEX1	PHL1	RNO1	SEA1	SDF1	TUL1

New Structure 5/3/1

Slow	LEX1				
Medium	LEX1		RNO1	SDF1	
Fast	LEX1	PHL1	RNO1	SDF1	TUL1

Splits reduced by 1 percentage point by changing network structure

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What is causing higher long zones?

- Imbalance between east/west coast in-stocks

	Fast	Medium	Total
West (RNO)	69.7%	33.0%	57.5%
East (LEX,SDF,PHL)	89.8%	58.7%	79.4%

- FC Shipping targets/caps

RNOÊs daily ship units = 27

Shipped from west to east = 27 · 16.0 = 11.0
Shipped from east to west = 11.8 + 1.2 = 13.0
Total Long Zones = 24.0

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Planning & Future Goals

- Reduce splits and long zones
  - Set optimal in-stock targets by FC
  - Plan product to FC allocation
- Long range planning
  - Support implementation of plan and development of S&OP
  - Model FC network throughput and storage capacity
  - Integrate inventory planning, allocation, and splits and LZ models
- Model and optimize network for 'Postal Injection'
- Optimize network for other initiatives
  - Drop Ship, POP, Pricing, Promotions, etc.
  - New inventory planning and fulfillment systems

- Transportation Management

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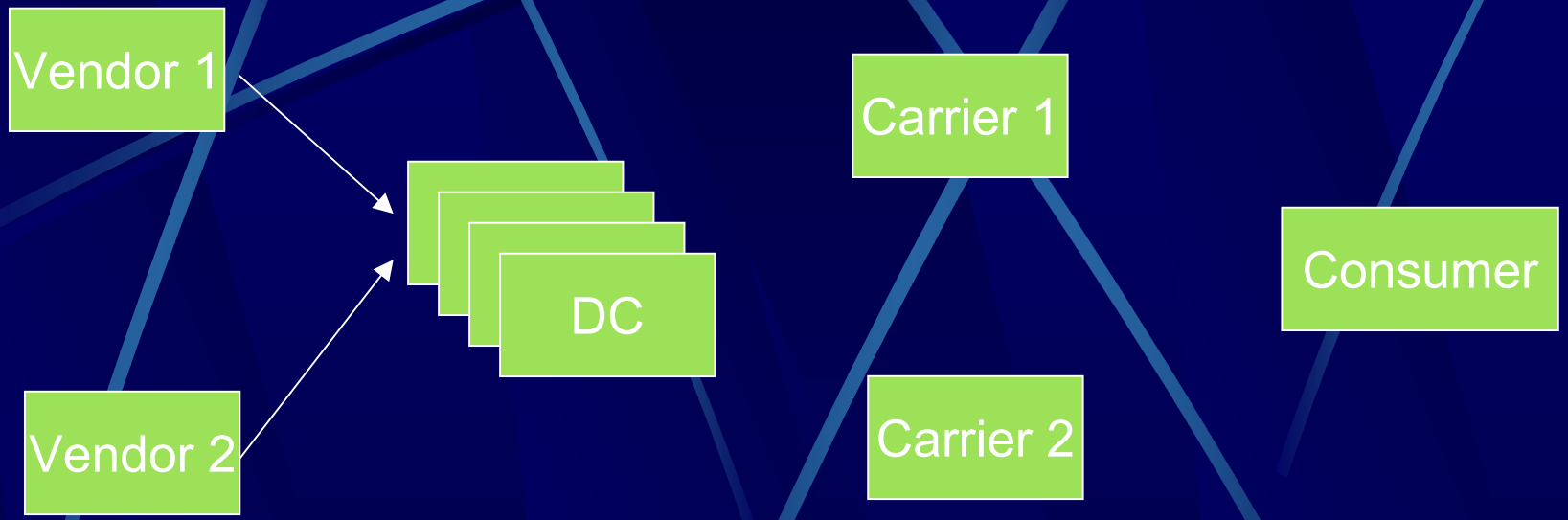
Transportation Management System



Third Party Provides Transportation Management System

- Planning
- Execution
- Freight Payment

Optimized Inbound Leads to Low Cost, Low Cycle Time

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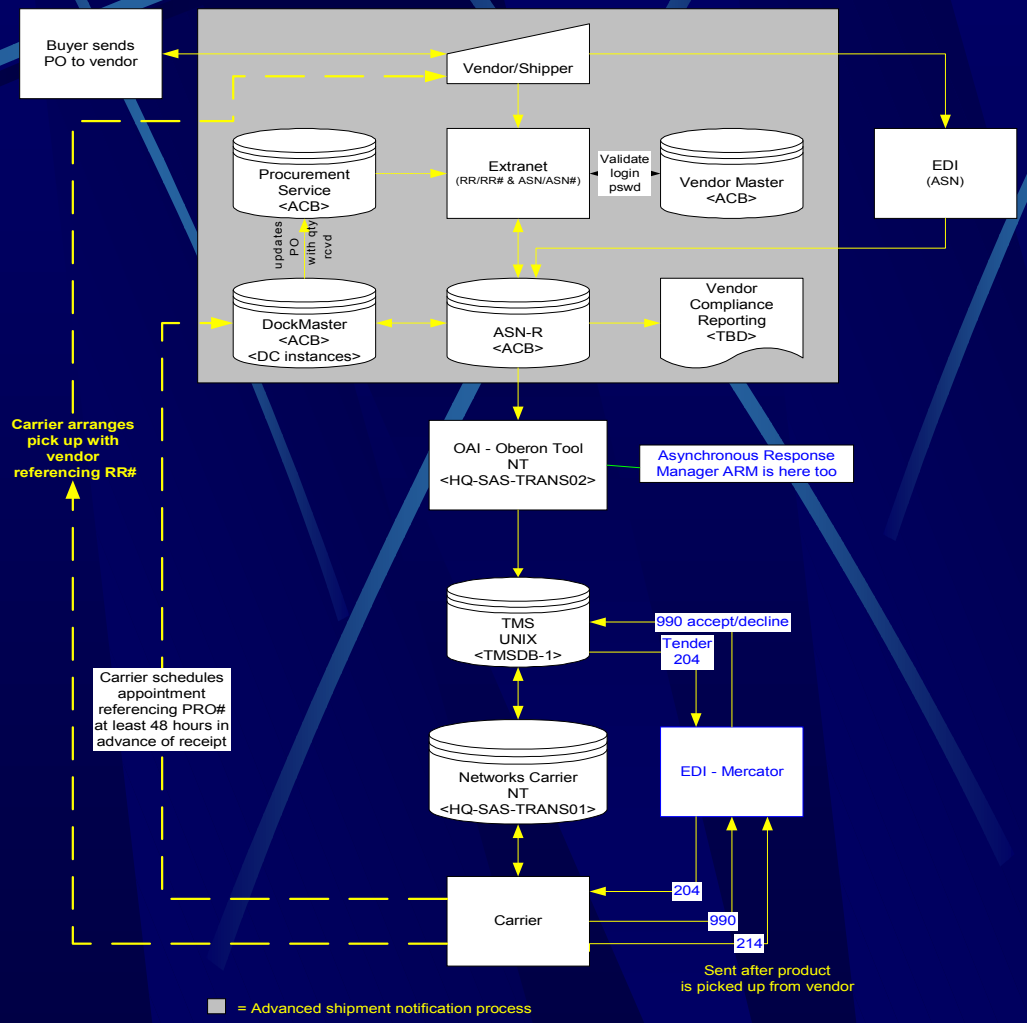
TMS process



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Outbound Transportation

- Carrier Negotiations
- Global Leverage
- Consolidation
- Innovation
- Backhauling
- Intelligent Systems

- Operational Excellence

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3. Operational Excellence

Distribution
Transportation
Inventory
Technology
Vendor Management
Customer Service

Process Improvement Tools

Decision Support Tools

Leadership

Continuous Improvement in Customer Experience and the Cost to Deliver It

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So…Some of The Same Tools and Systems Will Drive Value

- Total Quality Management = Teaming and Empowerment
  - Incredibly valuable given the importance of training/informing seasonal labor
  - A well-understood system always beats the best math
  - Execution is all about leadership
- Lean = Cycle Time Reduction
  - Lower Inventory
  - Better forecasts

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TQM and Lean Support Six Sigma

- Six Sigma = Systematic Reduction of Variation
  - Less inventory
  - Higher throughput
  - Lower cost
  - Higher predictability
  - More nimble
- We have definable processes, automatic data capture, and lots of opportunities for defects
- Don't have to worry much about underlying physics or chemistry!

Defining Success

- Double or triple throughput with no additional infrastructure
- Reporting much higher than 99% shipped before Xmas
- Reduction in defects to customer
- Network goals:
  - Increase shipping margins by reducing split & long zone shipments
  - Optimize traffic & consolidate/sort for minimum cost
  - Reduce lead time to customer (& working capital) with better tracking

Remember

- The woods are lovely dark and deep
  I have promises to keep
  And miles to go before I sleep
  And miles to go before I sleep