

Advances in Supply Chain Planning Tools

Nov 2008

Michael Watson

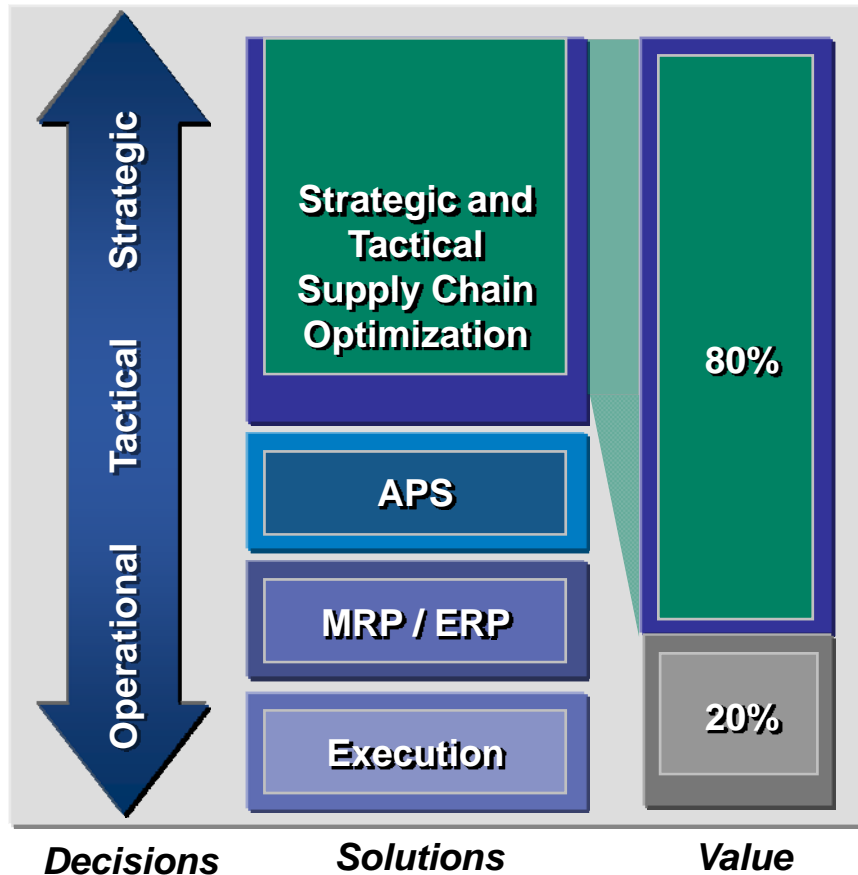
ILOG, Inc.

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A faint, grey world map is visible in the background of the bottom section of the slide.

LOGiCTOOLS Product Suite

- Introduction to Strategic Planning
- Network Design Introduction
- New Processes in Strategic Planning
- New Areas for Strategic Planning
- Advances in Optimization
- Tougher, More Sophisticated Decisions
- Wrap-Up



Source: AMR Research, BCI

Decisions include:

- Supply chain structure
- Production Planning and Scheduling
- Production Sourcing
- Inventory Strategies and Postponement

- **Crosses boundaries within an organization**
 - Sales, Finance, Operations– multiple plants may be multiple profit centers

- **Data**
 - A lot of data can be required
 - New types of data

- **Tough Optimization problems**

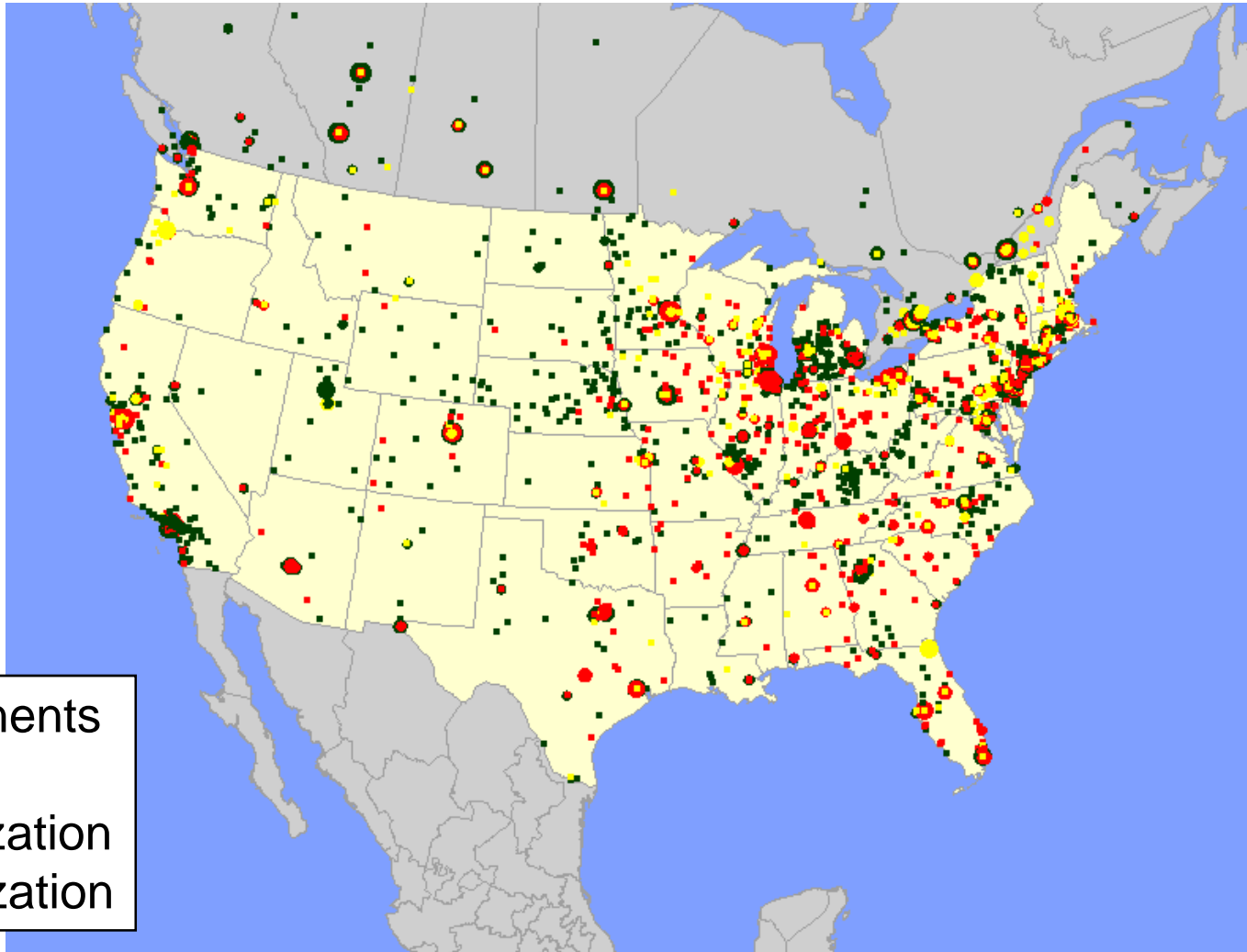
- **Decisions made with remaining uncertainty**
 - Future demand, future prices
 - Political stability, currency fluctuations
 - Ability to shape demand– new policies to attract customers

- **Implementation**
 - Changes suggested can be disruptive
 - Changes can be radical

- New Processes
- Applied to New Areas
- Optimization Advances
- More Sophisticated Decisions

- Advances in planning tools can help evaluate all drivers of costs in a complex environment
 - Data driven decisions can differ greatly from assumption based decisions
- No one supply chain strategy fits all organizations
 - More importantly: probably no single strategy fits all your different types of products and markets
- Many new aspects of mixed in with proven methods
 - Carbon modeling
 - Production scheduling and planning

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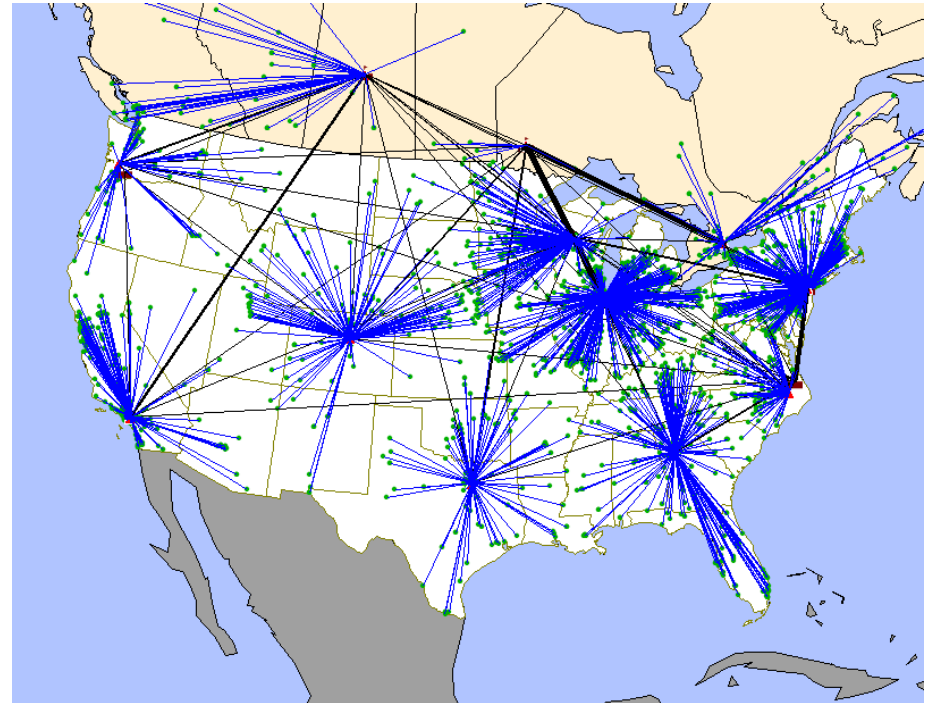
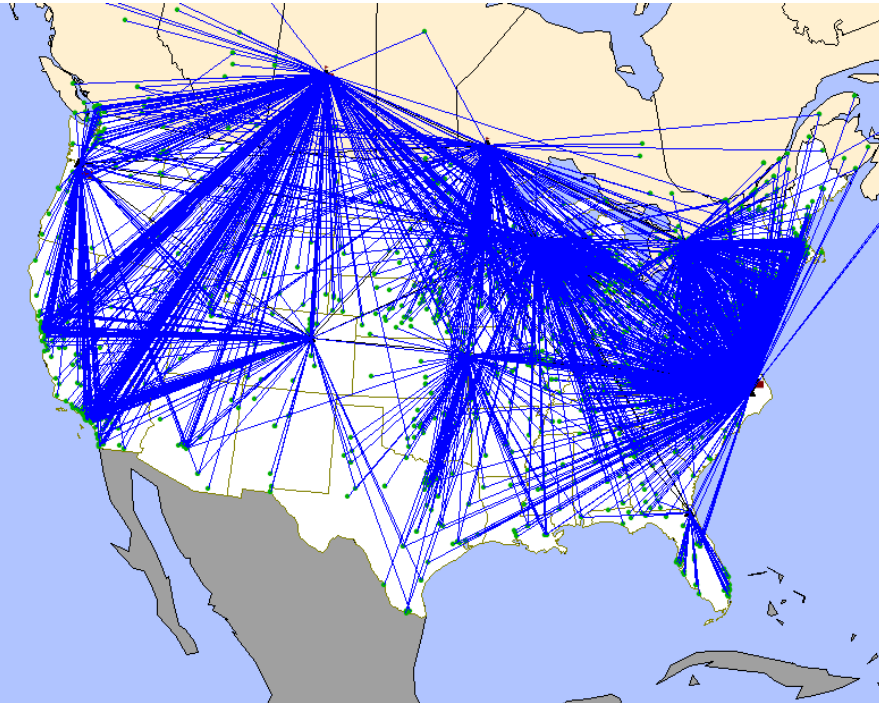


- Components
- Data
 - Optimization
 - Visualization

Solution Comparison



Changing the rules of business



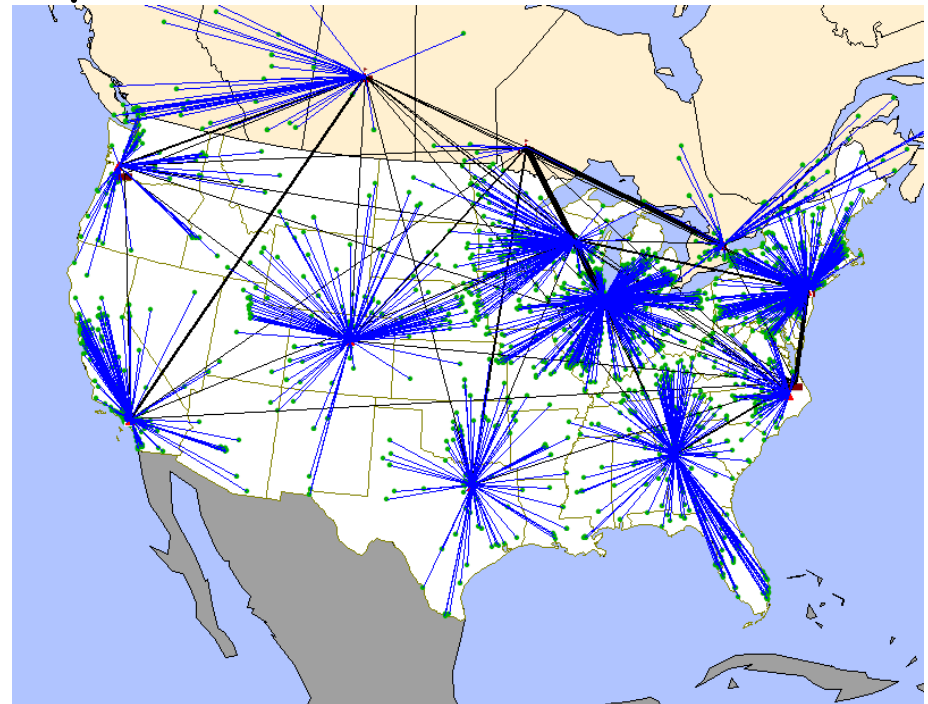
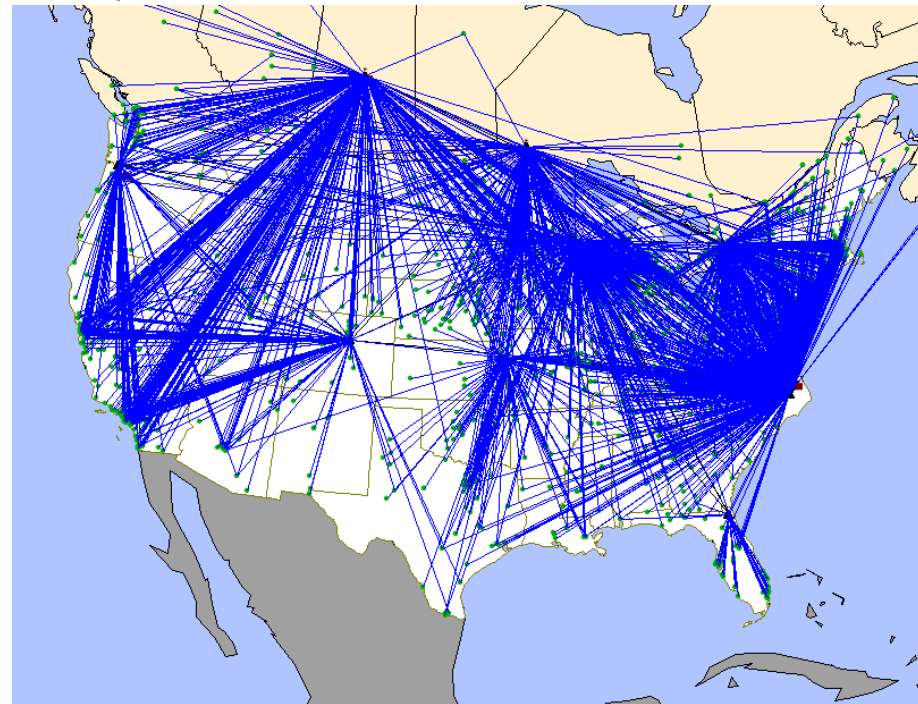
Making the Trade-Off Between Service and Cost



Changing the rules of business

Optimal Network For Cost

Optimal Network For Service



Savings: \$6 million
Service: 40% next day

Savings: \$3 million
Service: 80% next day

Which is Better?

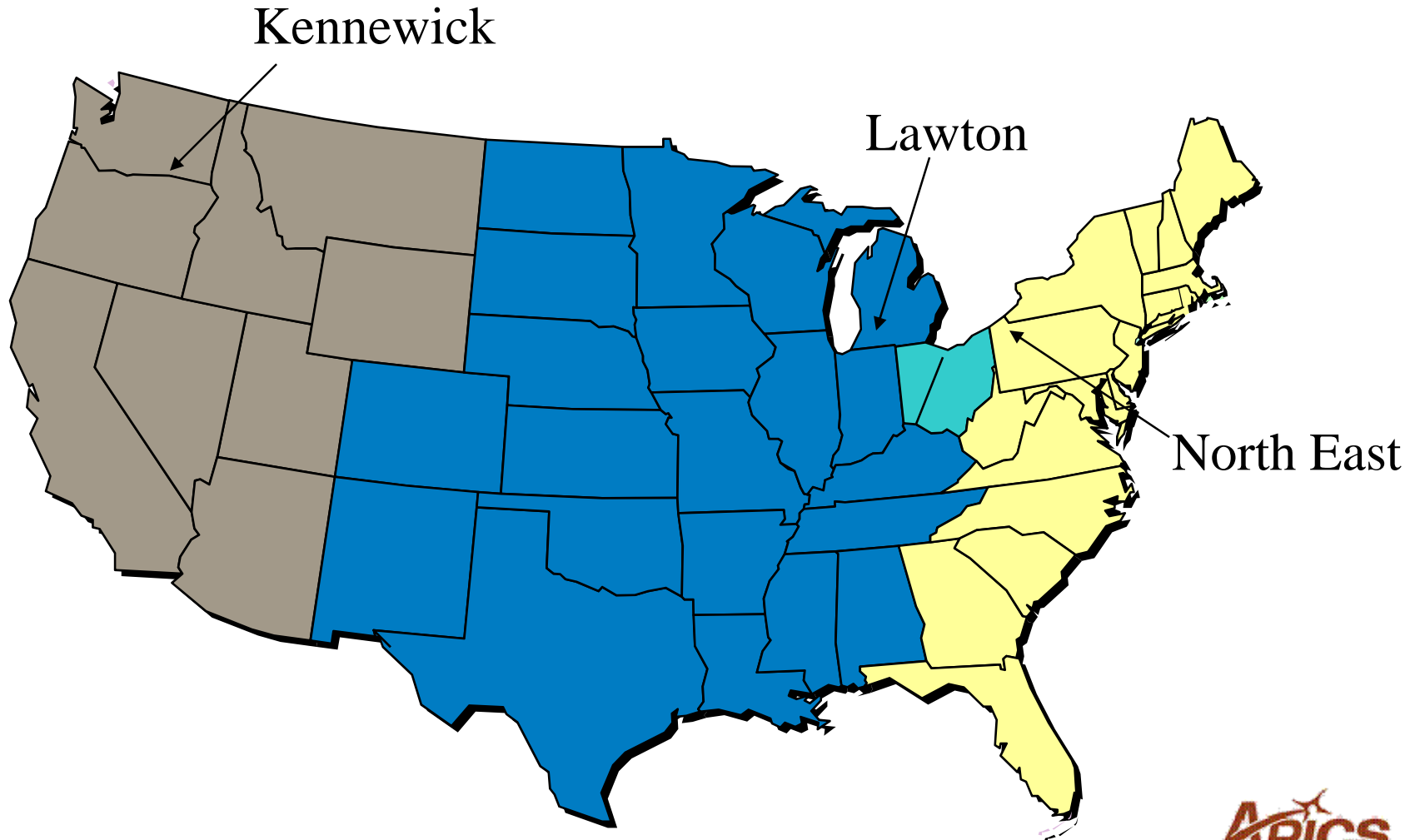


■ Situation

- Sales Team: Reduce service time and sales will increase
- Logistics Team: 3PL study indicates addition of 3 DC's reduces cost
- Planning Team: Addition of DC's will increase Inventory Costs

■ Project Objective

- Model existing supply chain to understand cost drivers
- Evaluate various business alternatives and recommend optimal network



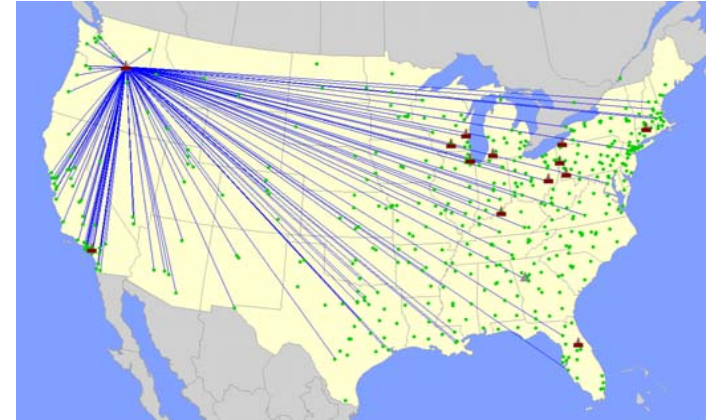
*Ohio is split between NE & LT

Existing Shipments to Customers

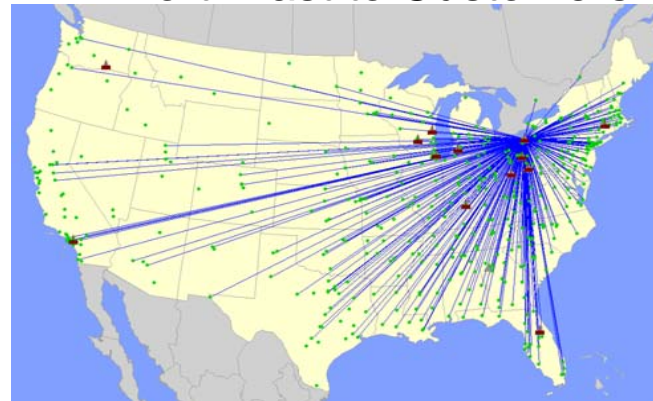
MidWest to Customers



NorthWest to Customers

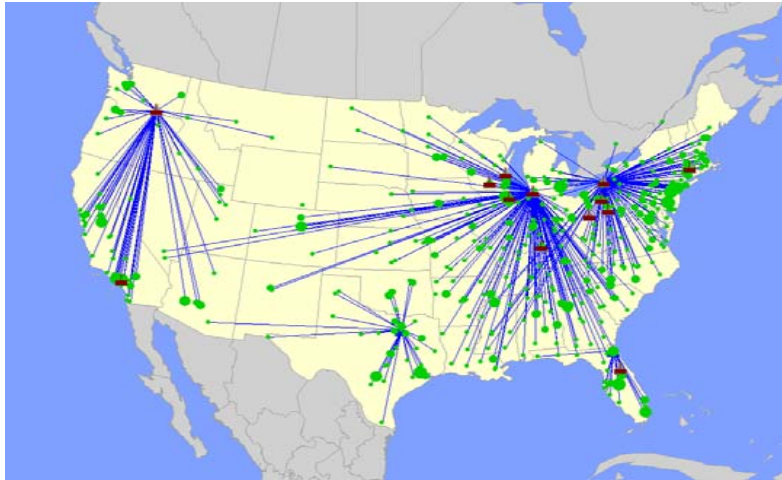


NorthEast to Customers

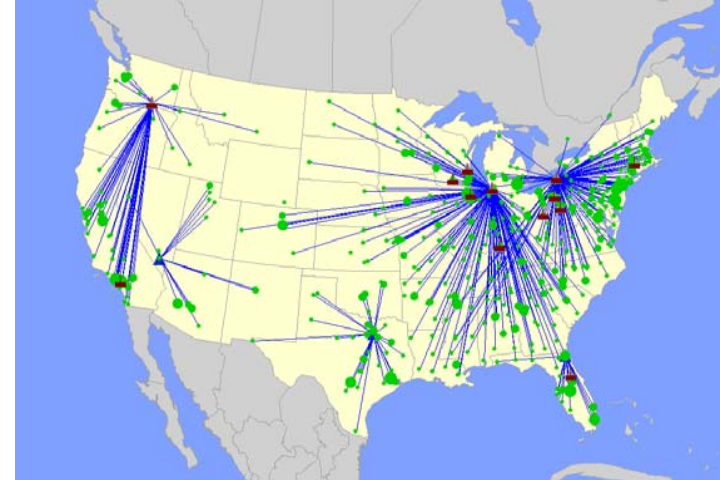


**Significant Out of Region Shipments and inter warehouse transfers:
Immediate savings without making any changes**

Addition of 2 DC's

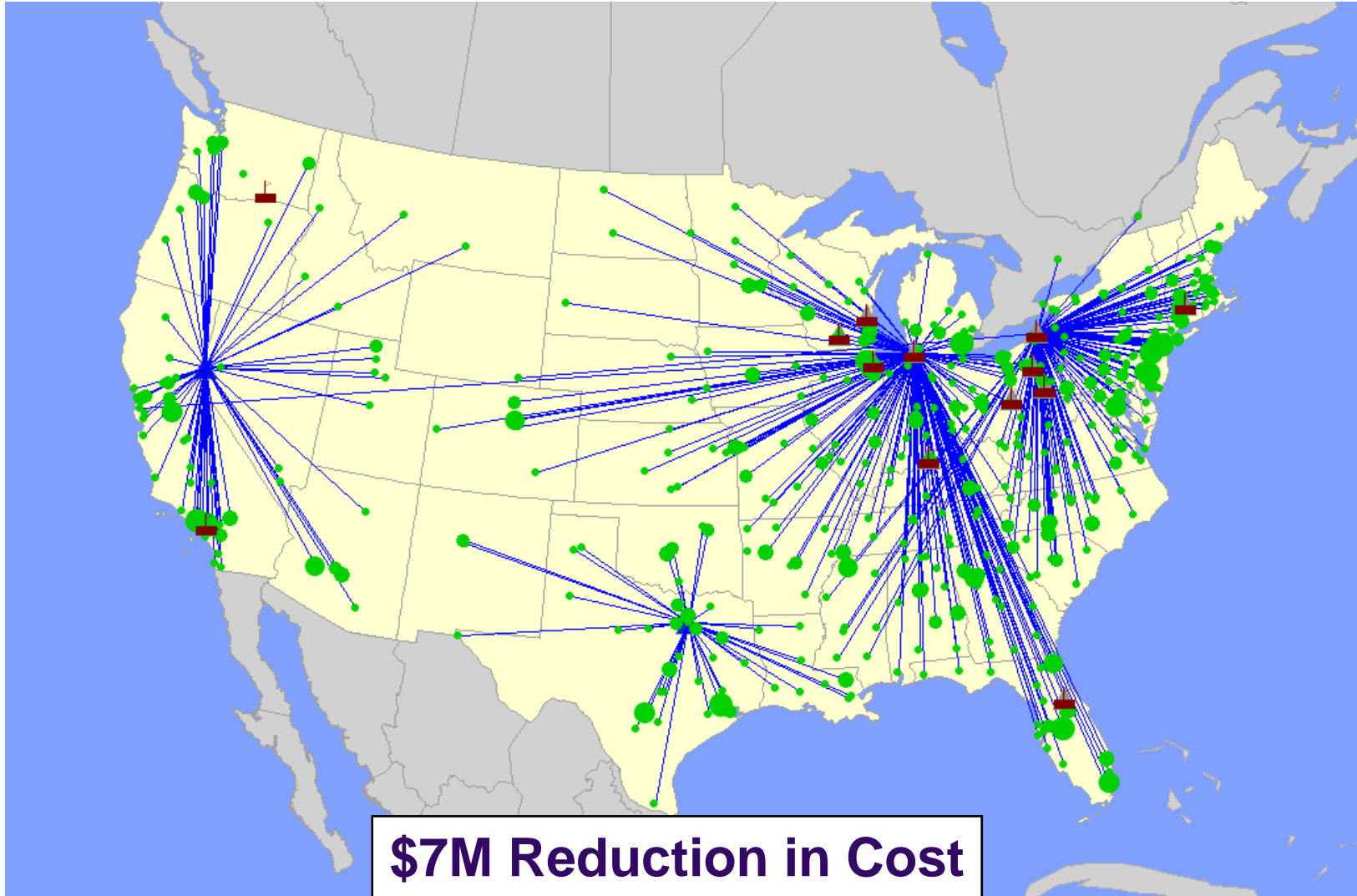


Addition of 3 DC's



30% reduction in distance to customer
Cost Reduction: \$300,000

Updated Network: Allow Closing of Plants and Re-Sourcing the Products



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Network Design in a Rapid Growth Business: Walgreens



Changing the rules of business

- Walgreens is the largest drug store chain in North America with 2003 Revenues of \$32.5B

- Currently has 4,229 stores
 - More than 50% opened within the last 5 years
 - 400-500 new stores open each year

- Currently has 12 DC's with a 13th under construction
 - Each DC serves 500-700 stores
 - Stores are within 250 miles of a DC

- Logistics costs
 - DC's: \$100 million to build
 - Transportation: \$100's million per year

Source: *Global Logistics & Supply Chain Strategies*, Nov 2003. pgs66-69 by Thomas A. Foster.



- **Network Modeling**

- Corporate logistics staff is ultimately responsible for new sites
- Use a network model to continuously evaluate the network and determine where and when new facilities are needed
- Modeling includes factors such as cost and service
- Results of the modeling effort find the “general area” for the new site

- **Picking a Site**

- Real estate team makes final selection
 - Available land
 - Zoning
 - Labor forces issues
 - Utilities
 - Tax issues
- Final sign-off at board-level

- Increasing importance of supply chain
- Value of modeling
- Capital approval process
- 1-Week Model to facilitate rapid turnaround

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Strategic Sourcing Case Study

Sold product throughout US to variety of customers

- Direct to distributors
- Through their own stores
- Through retailers

Wide variety of product

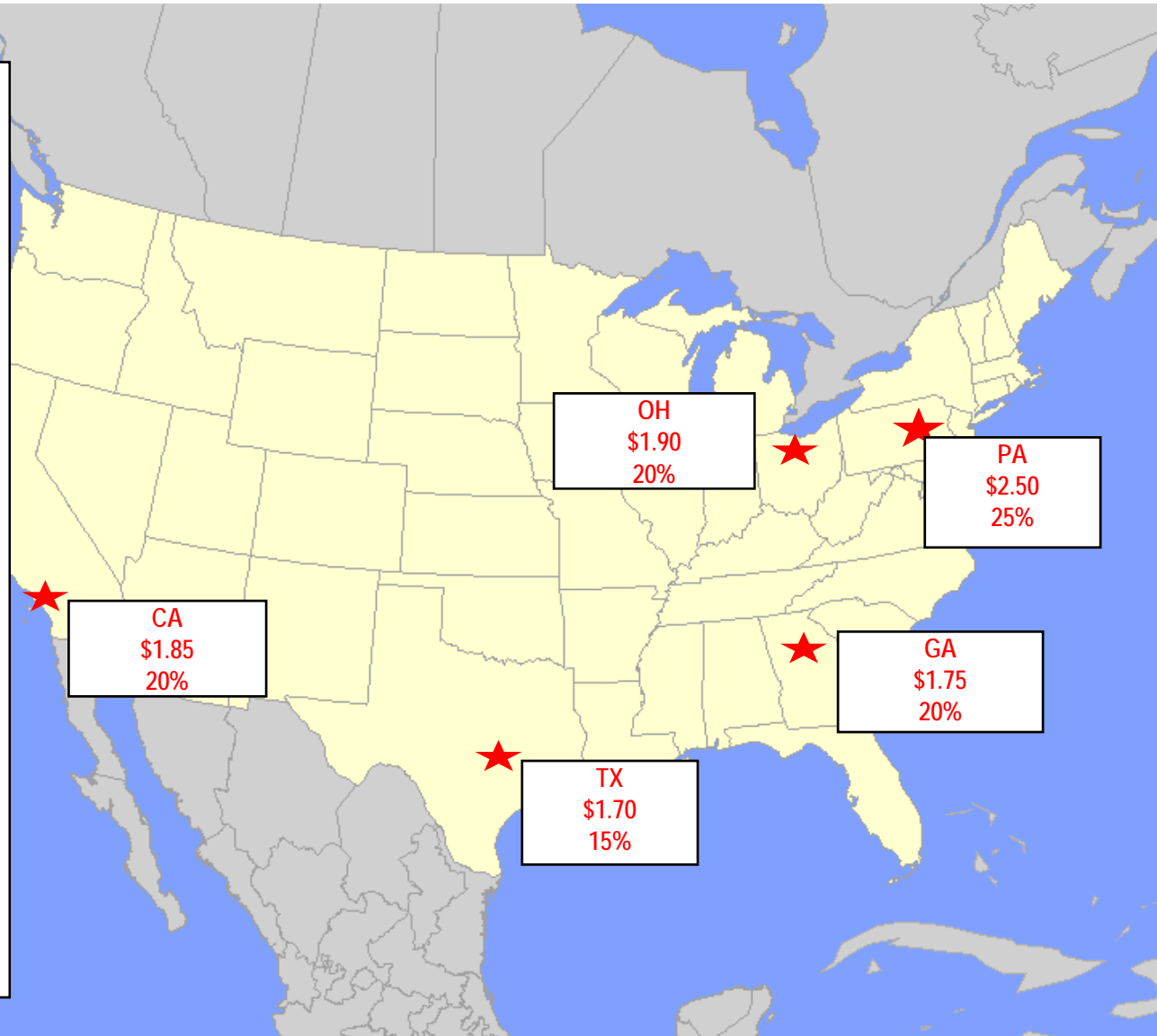
- 4,000 different SKU's
- 1,500 different base products

Batch Manufacturing

- Manufacturing done in batch, so there significant economies of scale if a single product is made in one location

Mfg Capability

- Each plant had many different processes
- Many plants can the same problem

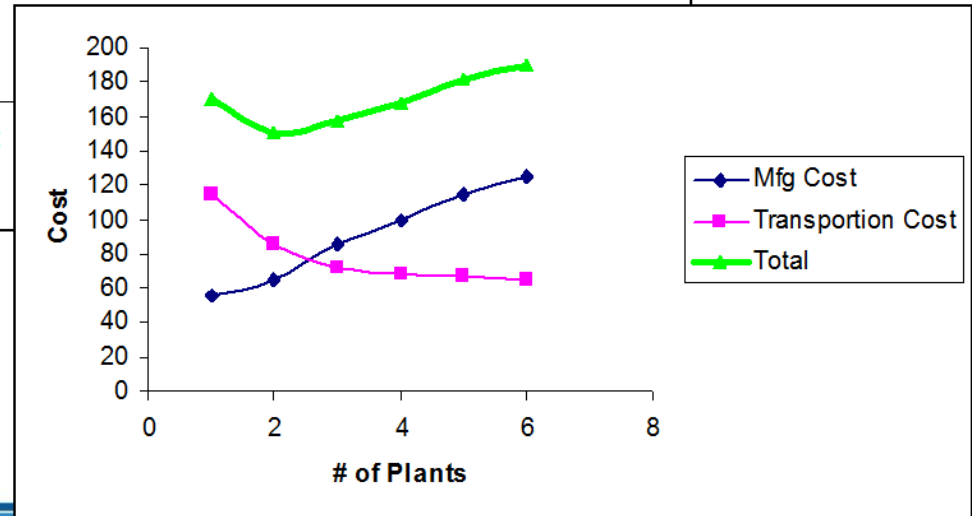
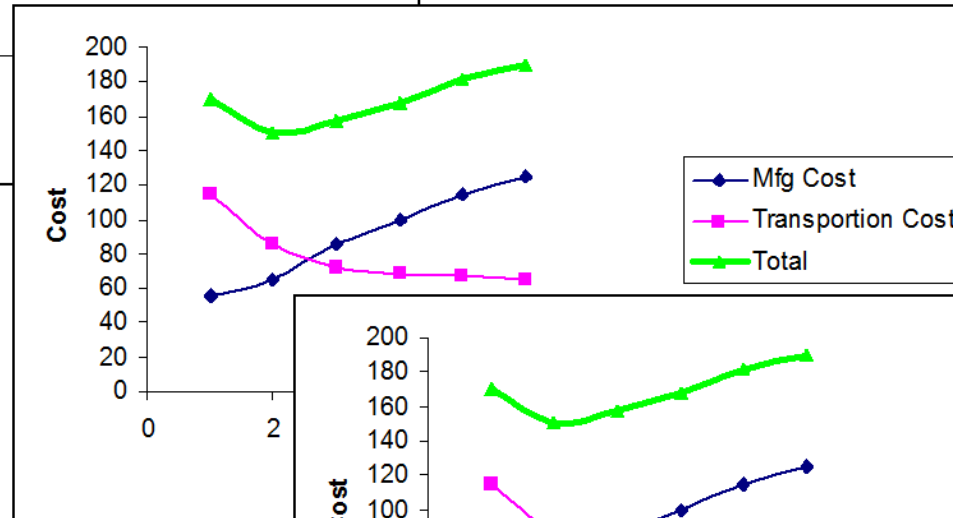
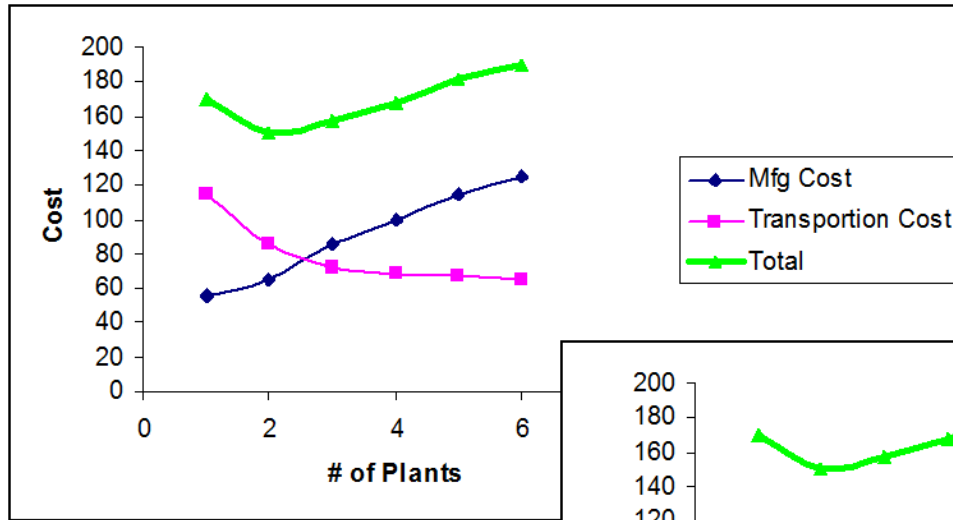


- Are products being made in the right location?
- Should plants produce a lot of products to serve the local market or should a plant produce a few products to minimize production costs?
- Should we close the high cost plant?

Key Production Sourcing Trade-Off



Changing the rules of business



Each part has the trade-off.

All parts compete for same capacity.

Raw Material Costs

- Invoice cost
- Freight cost
- % shrinkage
- Difficulty - Medium

Variable Mfg. Costs

- Variable Mfg. costs by process/by site
- Difficulty - High

Technical Capability

- Product Family
- Difficulty - High

Manufacturing Capability

- Demonstrated Capacity
- Difficulty - High



Yield Loss

- % of lost volume per 100 units
- Site Specific
- Difficulty - Low

Interplant Freight Costs

- Average run rates in from site to site
- Difficulty - Low

Existing Process

Sourcing decisions currently made in isolation

- ⇒ Decisions are made for small groups of products

Excel is the primary decision tool – Many drawbacks

- ⇒ Excel does not capture the many different trade-offs that exist in the supply chain
- ⇒ Excel can only calculate the costs for a given decision; it cannot make decisions

No formal data collection process

- ⇒ Data not collected systematically across the supply chain to make these decisions



New Process

Sourcing decisions made in context of entire supply chain

- ⇒ Decisions are made considering the entire supply chain

Sourcing decisions are made using Optimization Tool

- ⇒ Optimization model provides global optimization capability

Model automatically updates for on-going decision making

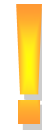
- ⇒ Developed process for automatically updating and maintaining the model so the decisions can be made on an on-going basis

■ Savings

- Identified immediate low volume SKU moves
- Identified \$4-\$10M in savings for moving base products
- Identified negotiation opportunities for raw materials

■ Details

- Moved 20% more volume into the high cost plant
- 80% of savings were from 10% of the production moves



■ Implementation

- Implementation done in phases, starting with the easiest/highest ROI
- 3-5 months to complete analysis, another 3-6 months to implement
- Expect to adjust plans as you go forward

- **Baseline**
 - Product A: 20% of the volume, 45% of the variable cost
 - Product B: 80% of the volume, 55% of the variable cost

- **Optimization**
 - Product A: 5% of the volume, 15% of the variable cost
 - Product B: 95% of the volume, 85% of the variable cost

- **Net change was an increase in total volume**

Carbon Footprint calculations for red wine

Cultivation

Fermentation

Winery

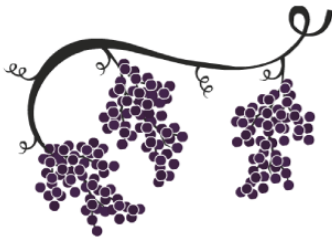
Containers

Transportation

Total

LOIRE VALLEY,
FRANCE

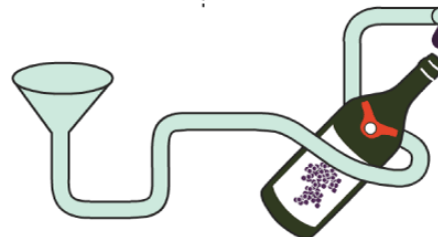
NAPA VALLEY,
CALIF.



Emissions are released by using energy to manage the land. Organic methods in France reduce this slightly.



Carbon dioxide is a byproduct of the chemical reaction that creates alcohol, a process that begins with grape crushing.



Energy used for lights, cooling tanks and pumps all result in carbon dioxide emissions.



The Napa wine is trucked to New York while the French wine is shipped for most of the trip and then trucked.

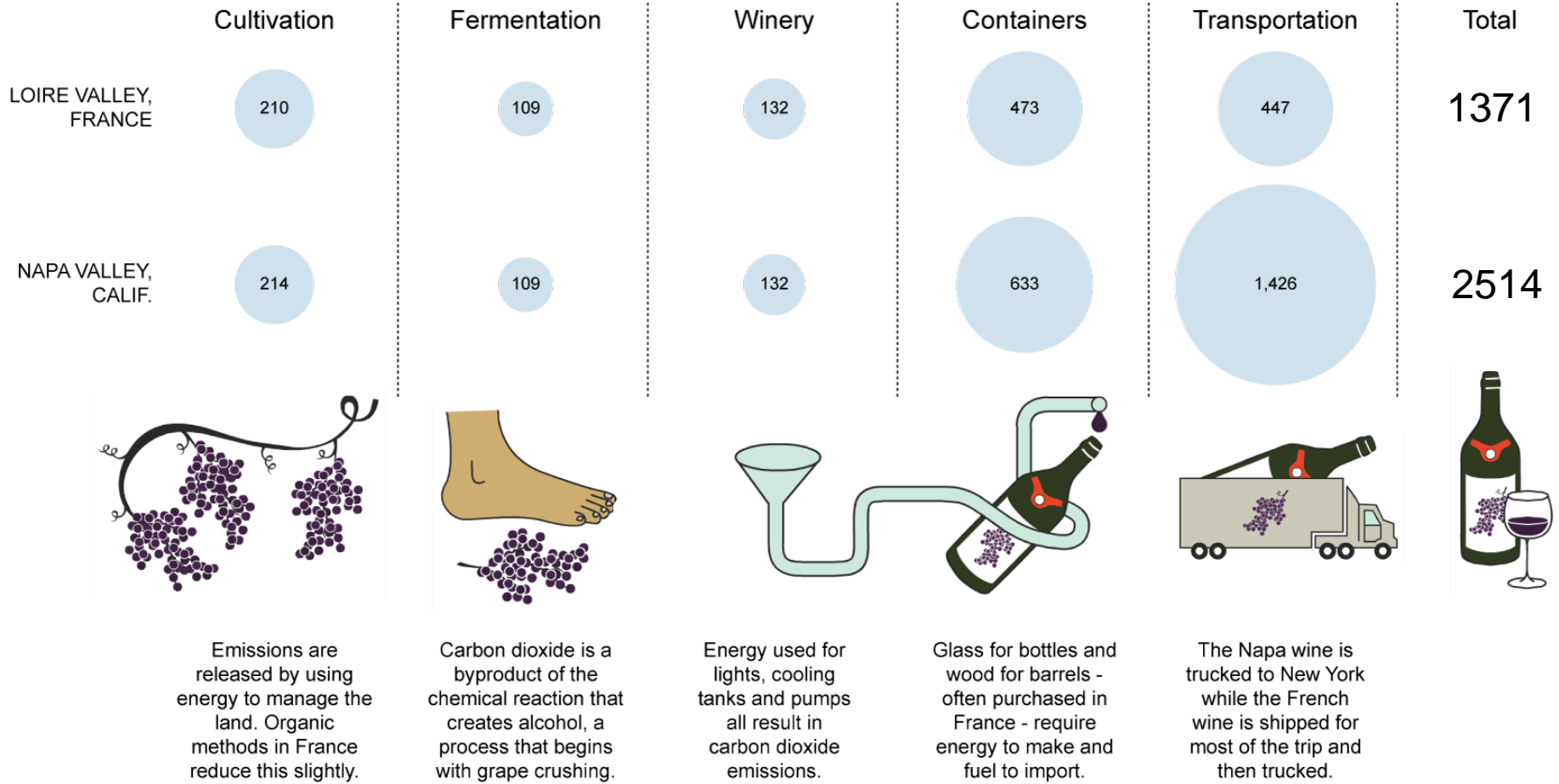


Source: NY Times, April 26, 2008

Carbon Footprint calculations for red wine



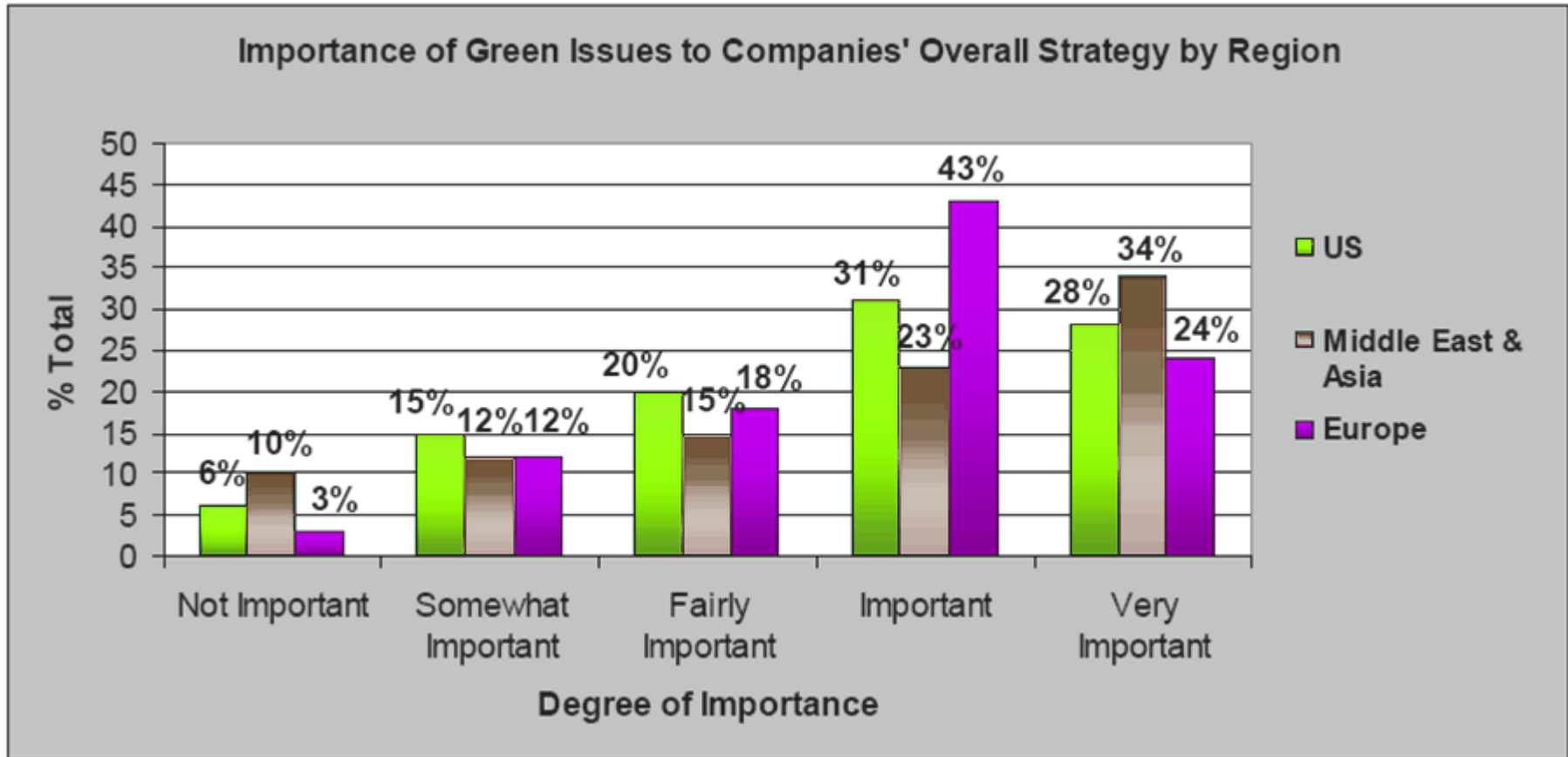
Changing the rules of business



Source: NY Times, April 26, 2008

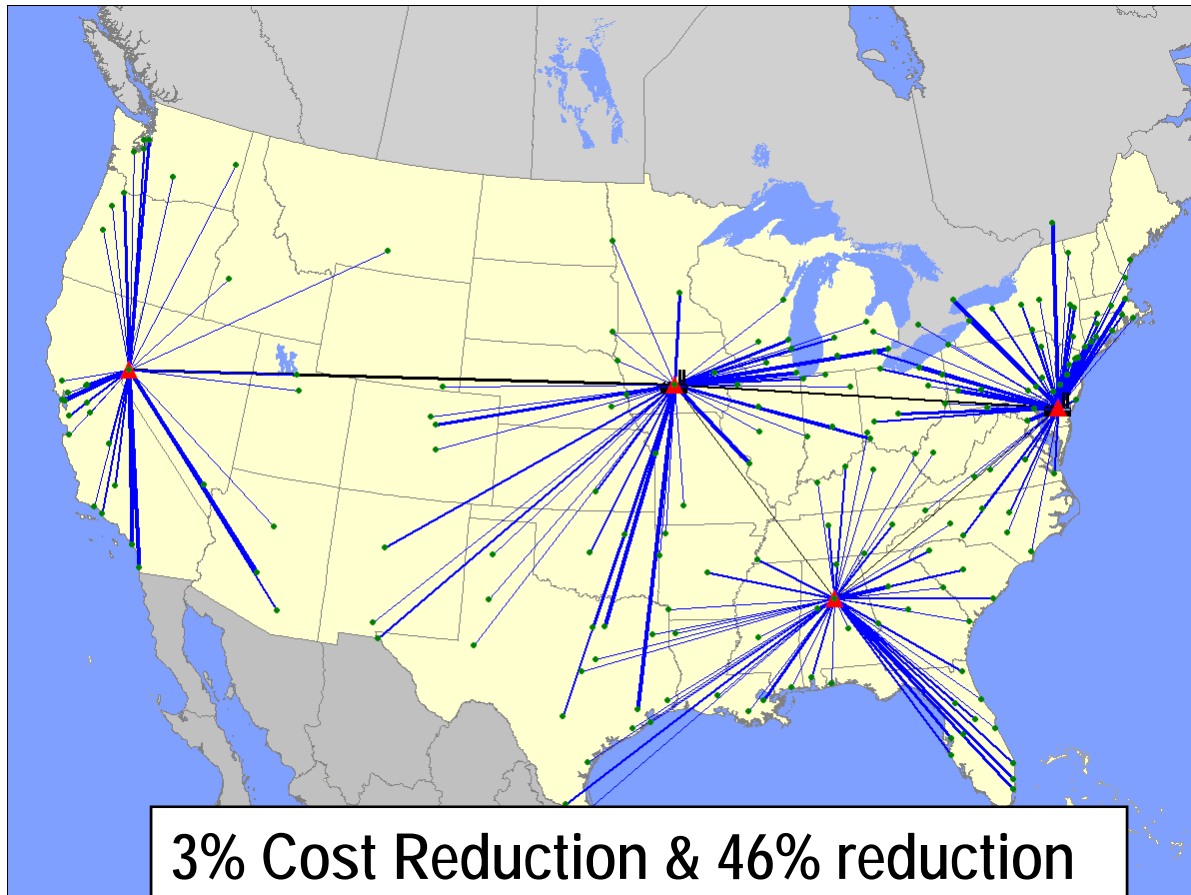


Green SC: Executives are Concerned



Eye for Transport Survey, Nov. 2007

- Apply network modeling to design a distribution network that satisfies customer demand at the lowest possible cost, while considering the Carbon Footprint of the new network



**3% Cost Reduction & 46% reduction
in average distance to customer**

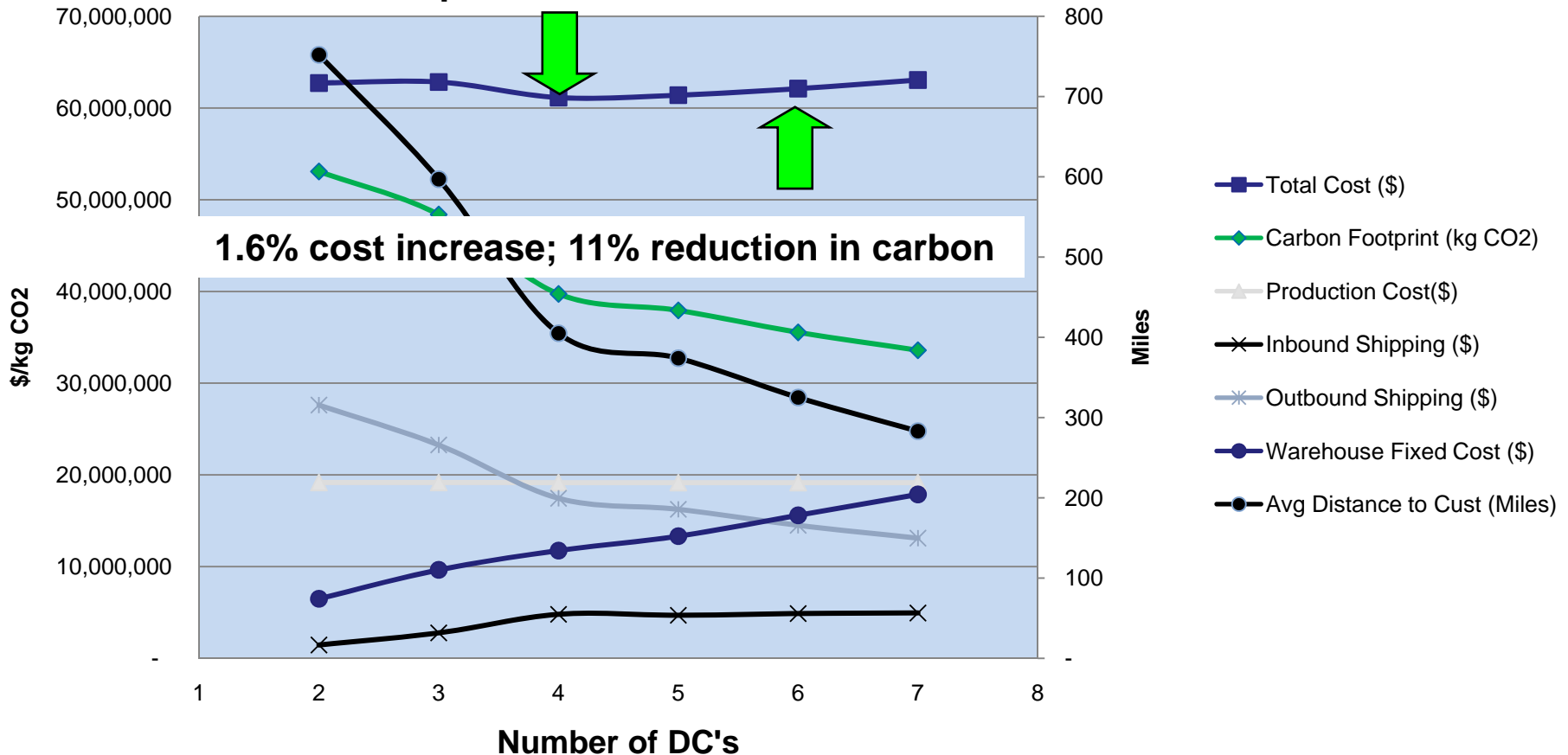
Trade-Off Curve Between Number of DC's, Costs, Service and Carbon Footprint



Changing the rules of business

Distribution Network with 2-7 DC Locations

Optimal Solution



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- Interest in optimization flowered
 - Numerous new applications identified
 - Large scale planning applications particularly popular
 - Funding widely available
- Significant difficulties emerged
 - Building applications was very expensive and very risky
 - 3-4 year development cycles
 - Developers and application owners had to be multi-faceted experts: Computer, Data, Algorithm, and Modeling skills necessary.
 - “Deploying an application was virtually impossible”
 - Technology just wasn't ready: LPs were hard and MIP was a disaster
 - **Result:** *Losing faith in the technology and much of that persists to this day.*

- Mid 80's:
 - There was perception was that LP software had progressed about as far as it could

- There were several key developments
 - IBM PC introduced in 1981
 - Brought personal computing to business
 - Relational databases developed: Separation of logical and physical allocation of data. ERP systems introduced.

- LP performance takes off
 - LP software becomes embeddable and flexible
 - Algorithms
 - Primal-dual log-barrier algorithms completely reset the bar
 - Simplex algorithms unexpectedly keep pace
 - Dual steepest-edge emerged as the winning simplex algorithm
- Data became plentiful and accessible
 - ERP systems became commonplace
- Popular new applications begin to show that Optimization can work on difficult, real problems
 - Business: Airlines, Supply-Chain
 - Academic: Traveling Salesman Problem

(Operations Research, Jan 2002, pp. 3—15, updated in 2004)

- **Algorithms (*machine independent*):**

Primal *versus* best of Primal/Dual/Barrier **3,300x**

- **Machines (workstations → PCs):** **1,600x**

- NET: Algorithm × Machine **5,300,000x**

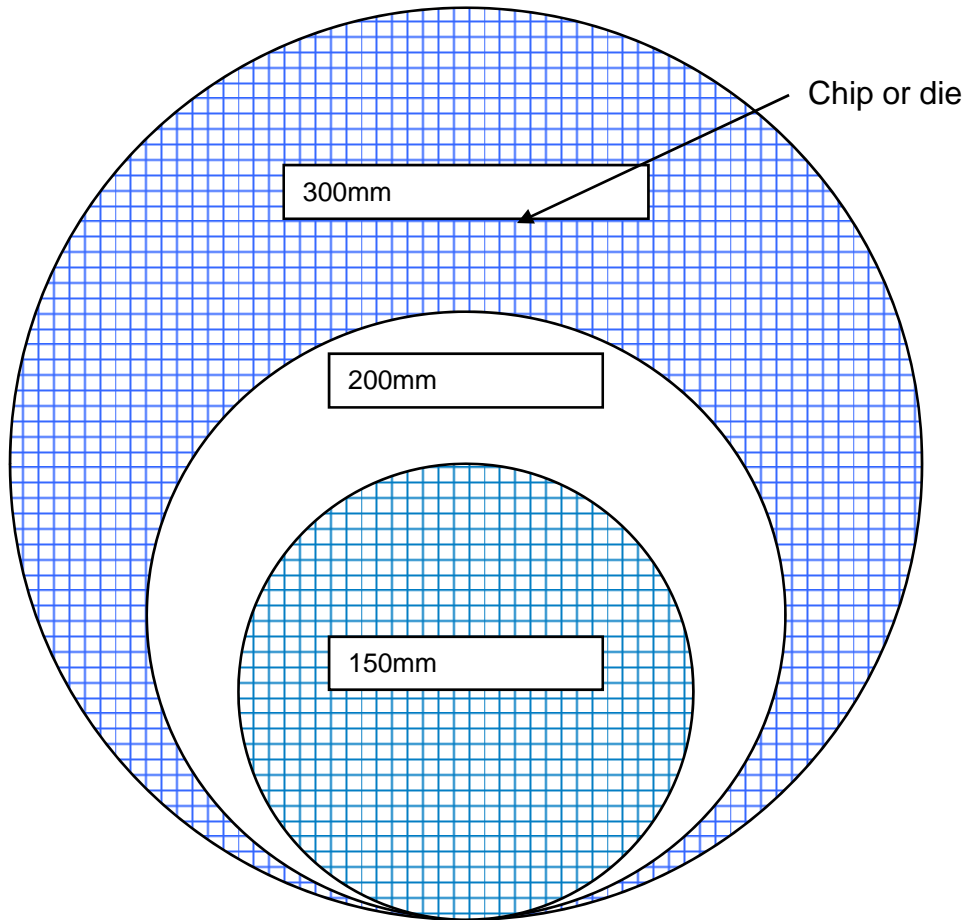
(2 months/5300000 ≈ 1 second)

More than Moore

- Optimization, specifically Linear Programming (LP), Mixed Integer Programming (MIP) and Constraint Programming (CP) is a robust technology for formulating and solving difficult resource application problems (like scheduling)
 - Optimization is the only technique guaranteed to find a feasible solution if it exists
 - Optimization is replacing many heuristic and rule-of-thumb based approaches because of better and faster results, in addition to feasible solutions
- Optimization is **now** fast enough and robust enough in the most challenging environments
 - Fab production scheduling (case study to follow)
 - Aircraft manufacturing and assembly planning and scheduling
 - Emergency landing optimization for airlines
 - Airline crew rebalancing in bad weather
 - Hospitals
 - Finance

- Leading the world in manufacturing
 - \$200+ billion/year business
 - \$40+ billion/year consumer of other products

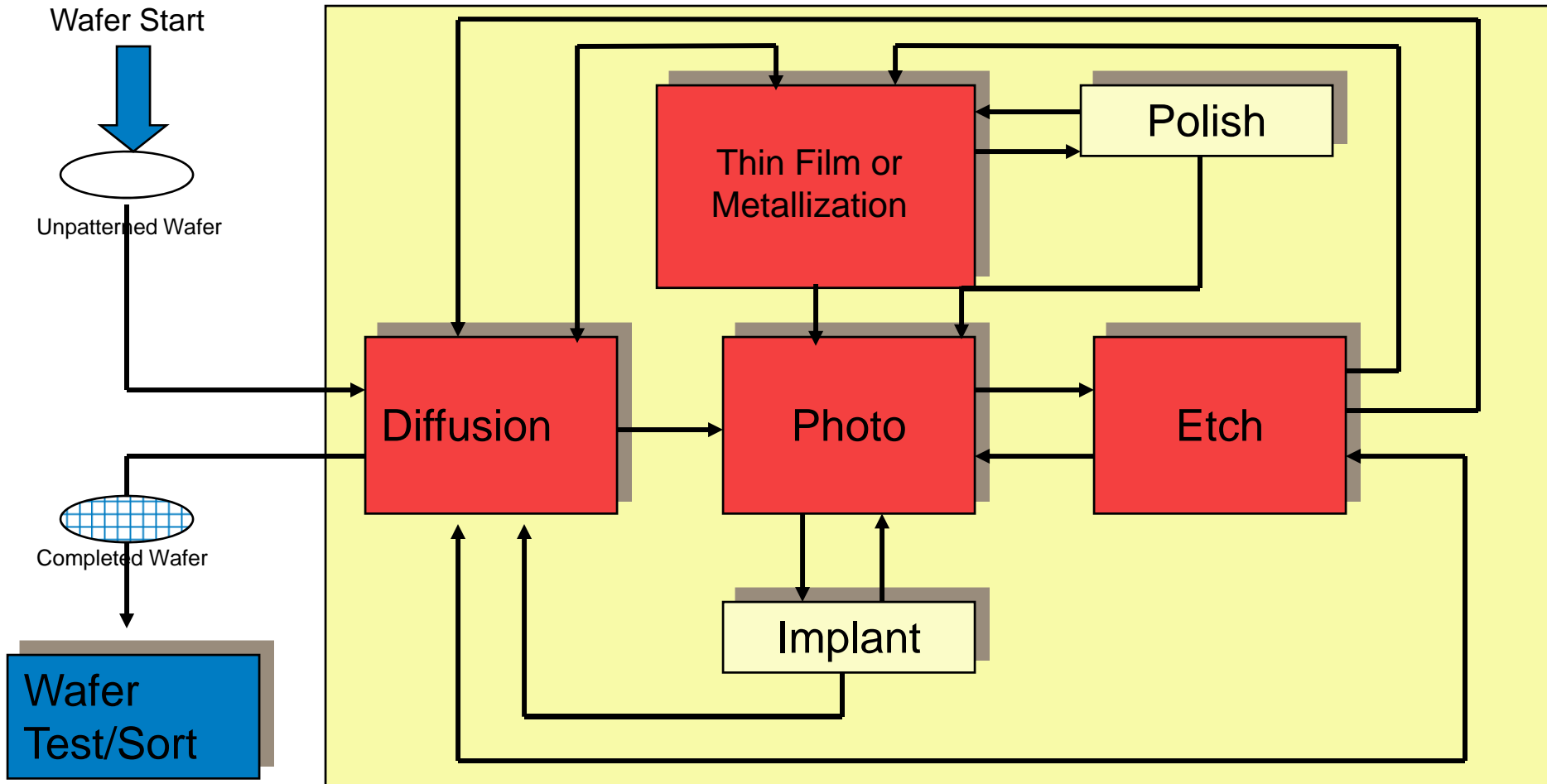
- Technology driven
 - Current generation of Fabs: 300 mm (12 inches) wafers
 - New Fabs cost \$3-4 billion



Some facts:

- **300 mm wafers current state-of-the-art**
- **500+ chips (dies) per wafer**
- **Process may require over 500 steps in 50 or more “layers”**
- **Processing occurs in lots of 6-25 wafers**
- **Takes 1-3 months to process a lot**

Main front-end processes



- Opened Summer 2002
- **Fully automated** production environment
- **All lots dispatched to tools without human intervention**

15,000 dispatches a day

Run time on 2 GHz processor:
5 minutes



- IBM B323 / Diffusion Area

Results vs. Baseline	FRN	WET
Throughput	+8.6%	+6.9%
Cycle Time*	-25.3%	-8.2%

Bixby, R., Burda, R., and D. Miller, *Short-Interval Detailed Production Scheduling in 300mm Semiconductor Manufacturing Using Mixed Integer and Constraint Programming*, ASMC 2006.

*Cycle Time = Processing time + Idle time

- IBM B323 / Lithography Area

Results vs. Baseline	Integrated Steppers
Throughput *	+8.6%
Cycle Time	21.7%

* Bottleneck tools

- **Diffusion + photo achieved Fab-wide 6% cycle time reduction**
 - Value of 300 mm wafer: \$4,000
 - Base 20,000 wafers/month throughput and 6% cycle time reduction means 1200/wafers increased throughput
 - $12 \text{ m/y} \times 1200 \text{ w/m} \times \$4,000/\text{w} \approx \$60\text{M/y}$ revenue
 - 25-50% profitability/wafer
 - **ROI: \$15M-\$30M/year**

- Previous methodologies use a **rules-based dispatching paradigm** rather than a **true scheduling approach**
 - These methodologies work by responding to individual requests from tools for work.
 - When such a request is received, the software must respond in a matter of seconds by selecting a lot to be dispatched from a list of available lots

- The approach offers two distinct advantages:
 - First, since it constructs a full, shift-length schedule, it is anticipating the effects of future dispatch requirements.
 - A second, key advantage, is that this approach looks across all tools in a tool group when constructing a solution, thus producing much better balancing of work in progress.

Fresh dairy manufacturing process



- Setup times



- Semi-finished product



Milk

- Cow
- Soy

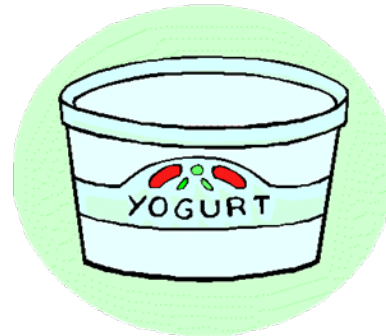
Pasteurizers

Fermentation tanks

- Capacity
- Batch size

Storage Tanks

- Connectivity
- Compatibility



Finished Product

- Safety stock
- Shelf life



Filling Lines

- Multi-purpose
- Setup times
- Cleaning in place

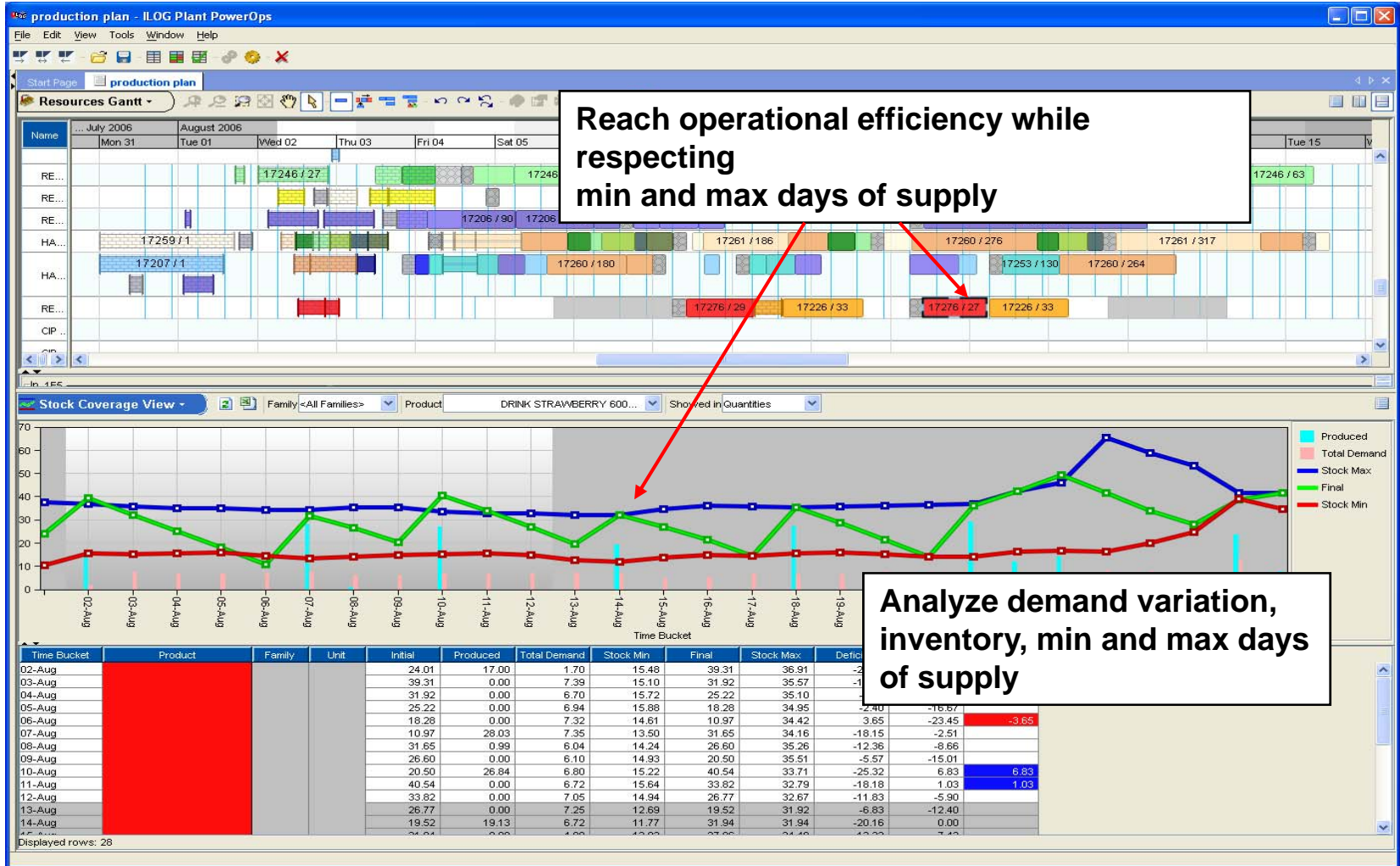


- Meeting Demand
 - High demand variability
 - Short shelf life of intermediate products and finished goods
 - Relatively long production lead times (3 to 4 days)
- Manufacturing Efficiency
 - Maximize resource utilization, operational efficiency and throughput
 - Minimize waste
 - Maximize manufacturing predictability
 - Management of tanks, fill rate, equipment connections
 - Management of batching and cleaning policies
- Quality
 - Compliance to traceability and sanitary regulations

Integrated planning and scheduling at Danone



Changing the rules of business



- Workload view with the layout focused on utilization of resources

Workload Table				Layout Utiliza...		
Resource	Capacity	Rank	7-Dec	8-Dec	9-Dec	
			Average load	Average load	Average load	
pasteurizer 1		0	36%	38%	14%	
pasteurizer 2		1	27%	52%	26%	
fermenter 3		2	58%	87%	14%	
fermenter 4		3	85%	72%	72%	
fermenter 5		4	87%	72%	0%	
fermenter 7		5				
fermenter 8		6	0%	86%	29%	
fermenter 9		7	0%	87%	72%	
fermenter 10		8	72%	58%	29%	
fermenter 11		9	100%	87%	29%	
tank 4		11	10%	10%	10%	
tank 7		13				
tank 8		14	0%	11%	4%	
tanks 3 11		18	10%	12%	3%	
tanks 5 9 10		19	7%	10%	5%	
line 4		21	80%	81%	83%	
line 7		23				
line 8		24	0%	88%	33%	

- Resource families:

Workload Table				Layout Utiliza...	
Resource	Capacity	Rank	7-Dec	8-Dec	
			Average load	Average load	
pasteurizer	2	0	51%	67%	
fermenter		2	15%	63%	
tank	8	10	65%	87%	
line		18	51%	89%	

Create and compare scenarios

KPI Comparison Panel					X
KPIs	Initial	Standard	SupplyChain	Factory	
Inventory Excess (t)	1,136.65	513.81	453.78	579.74	
Inventory Deficit (t)	22,021.54	17,768.21	16,049.80	19,003.19	
Daily Inventory Excess Incidents	60.00	35.00	32.00	41.00	
Daily Inventory Deficit Incidents	195.00	179.00	170.00	177.00	
Operational Efficiency (%)	62.92	63.18	63.28	63.72	
Operational Utilization (%)	73.91	86.48	90.75	83.92	
Average Cycle Time (h)	50.71	45.55	41.10	47.31	
Total Cleaning Time (h)	134.65	178.65	192.92	164.65	
Total Setup Time (h)	0.00	0.00	0.00	0.00	
Average Compactness (%)	99.87	98.64	94.93	97.48	
White Mass Waste Cost (\$)	0.00	0.00	0.00	0.00	
Fruit Change Waste Cost (\$)	0.00	0.00	0.00	0.00	
Packaging Change Waste Cost (\$)	0.00	0.00	0.00	0.00	
Max Direct Labor (people)	0.00	0.00	0.00	0.00	
Manpower (man.hours)	0.00	0.00	0.00	0.00	

Information System

- Full SAP integration
- Modeling of both finished and semi-finished products
- Repeatable core-model

User

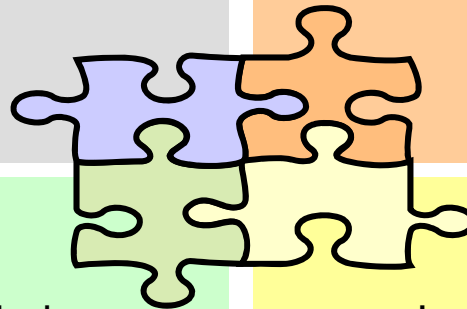
- Very good user acceptance
- Easy to learn, easy to use
- Decision support system for planners with plan editing capabilities

Organization

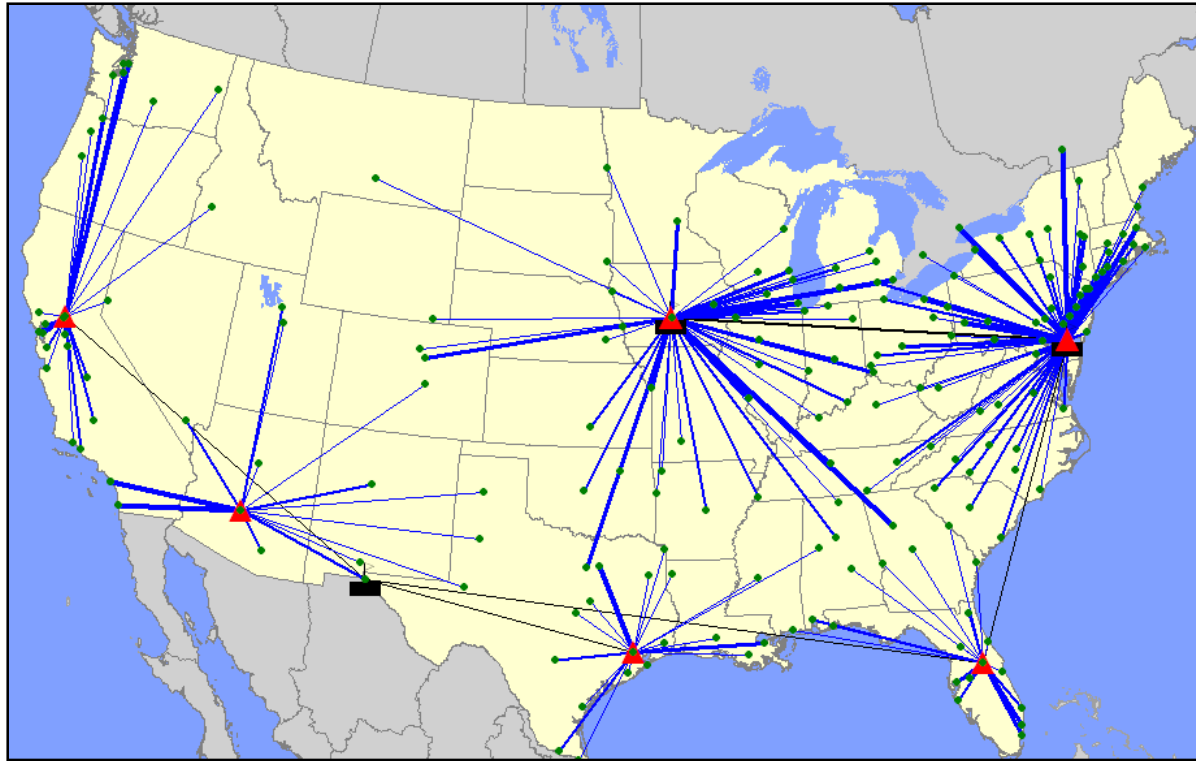
- Manufacturing and Supply Chain are using the same tool
- Daily (weekly before) planning
 - Improve reactivity
- Detailed planning delivered to manufacturing

Process

- Improve
 - Operation Efficiency/Utilization
 - Service level
 - Inventory corridor
- Deliver executable Plan
 - Finished products & white mass
 - Cleaning & changeovers
- Planning and scheduling integrated



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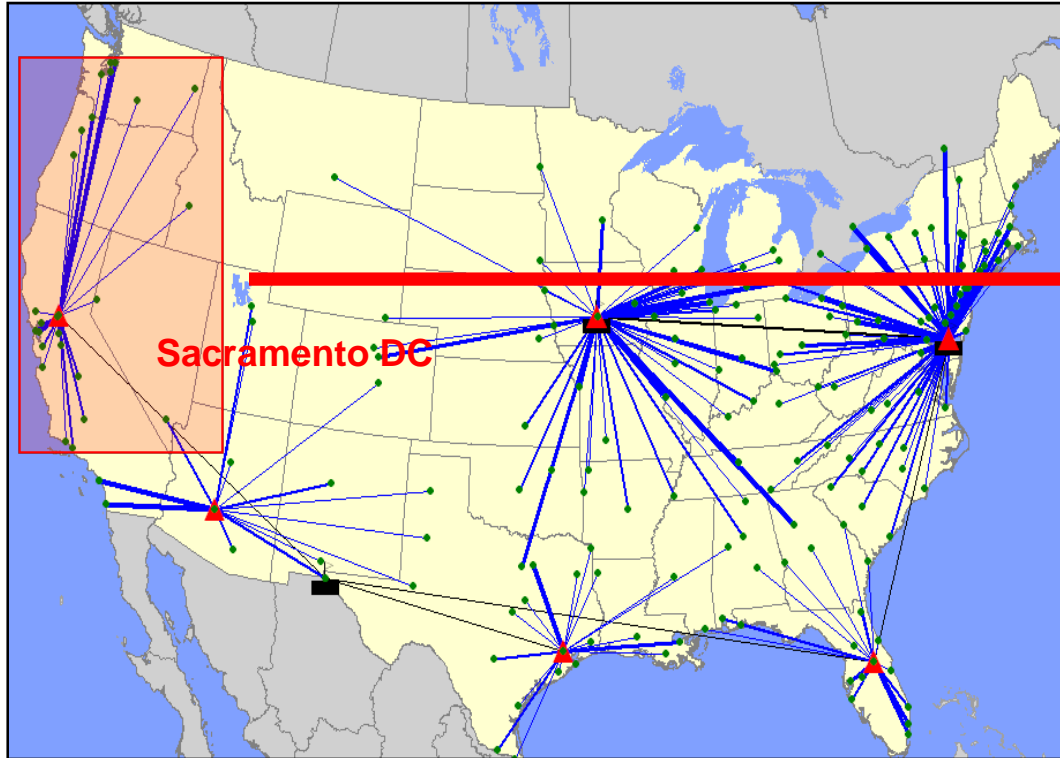
- Opens a Plant in Juarez, Mexico
- Opens four additional distribution locations:
 - Sacramento
 - Phoenix
 - Houston
 - Orlando

Total Cost: \$63,000,000

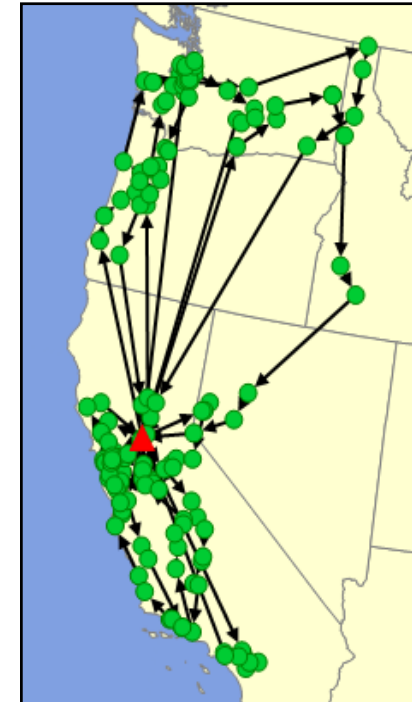
Average Distance to Customers: 330 miles

9% Reduction

56% Reduction



Sacramento DC



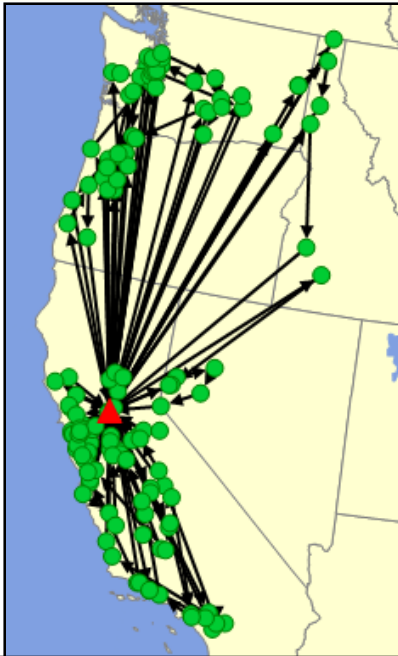
Annual Snapshot
Total Weight Delivered = 19MM lbs
- Avg Week 375K lbs
Total Transportation Cost = \$1.5MM
- Avg Week \$28.6K per week

Typical Week
Total Weight Delivered = 380K lbs
Total Transportation Cost = \$29.4K

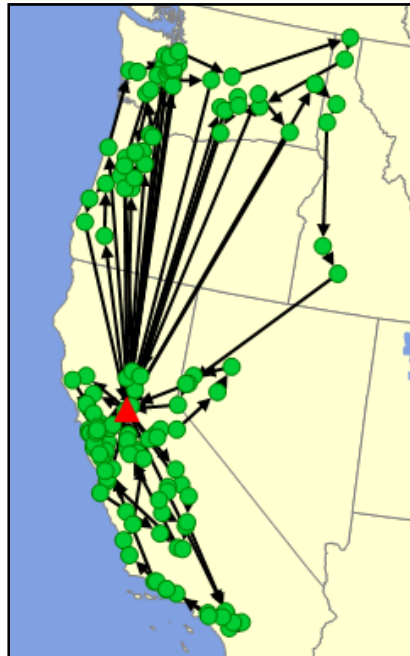
- Within 3% of LNP Weekly

Avg

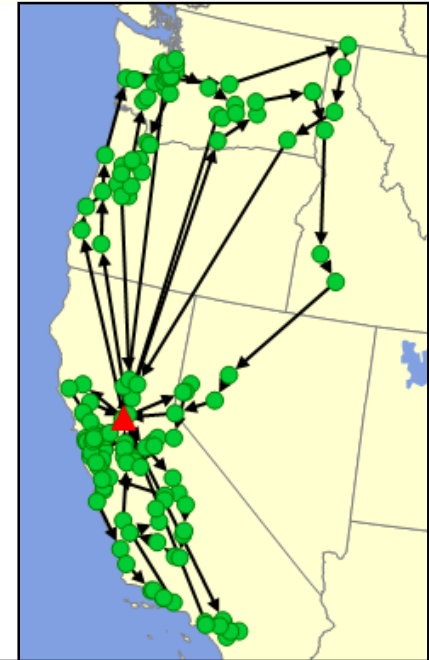
Shipment Routing Evaluation



Each Customer is promised delivery on a specific day (5 Time Windows)



Each customer is promised delivery during a portion of the week (2 Time Windows)



Deliveries can be made at any point throughout the week (1 Time Window)

	Value
Number of Vehicles	21
Total Distance	34,386
Deadhead Distance	11,621
TOTAL COST	\$88,301

37% Savings

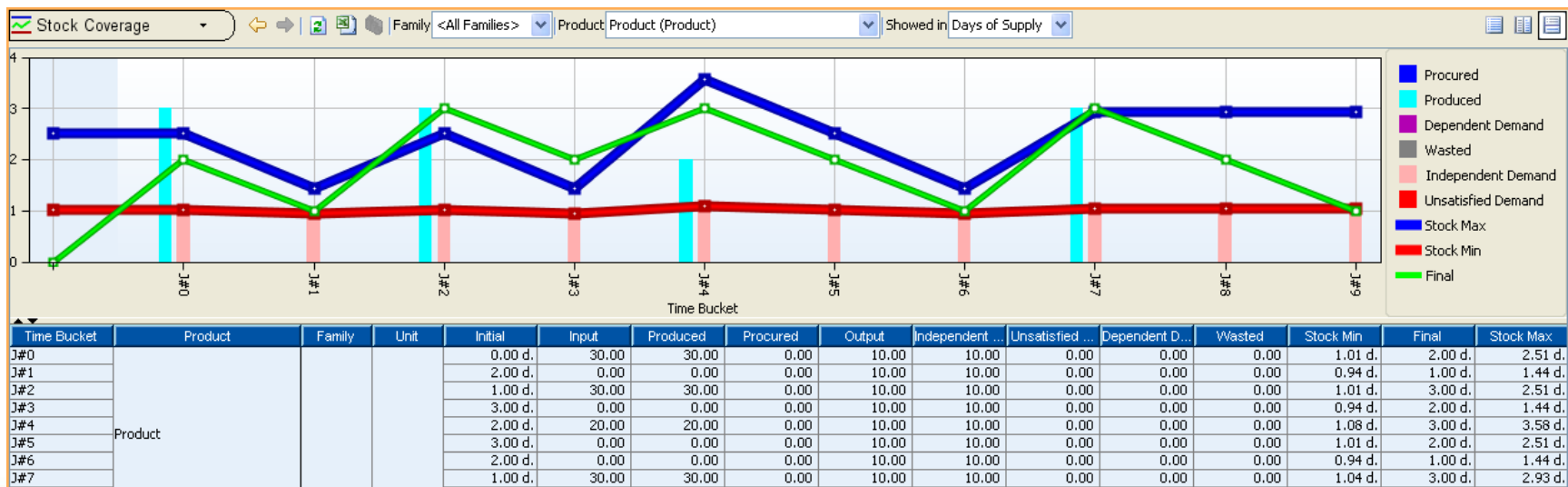
	Value
Number of Vehicles	13
Total Distance	21,320
Deadhead Distance	5,595
TOTAL COST	\$55,877

+ 30% Savings

	Value
Number of Vehicles	6
Total Distance	11,001
Deadhead Distance	1,489
TOTAL COST	\$29,369

- Traditional approach
 - Compute safety stock based on demand variability, fill rate and estimated production lead time
 - Compute production plan (i.e. lead time) based on demand and safety stock

- Dynamic safety stock
 - Inventory optimization and production planning integrated → global optimization



- Introduction to Strategic Planning
 - Network Design Introduction
 - New Processes in Strategic Planning
 - New Areas for Strategic Planning
 - Advances in Optimization
 - Tougher, More Sophisticated Decisions
- Wrap-Up

- Advances in planning tools can help evaluate all drivers of costs in a complex environment
 - Data driven decisions can differ greatly from assumption based decisions
- No one supply chain strategy fits all organizations
 - More importantly: probably no single strategy fits all your different types of products and markets
- Many new aspects of mixed in with proven methods
 - Carbon modeling
 - Production scheduling and planning