CHAPTER FOUR

INVENTORY IN SUPPLY CHAIN STRATEGY

Although it is often treated as such, inventory is not an end but a means to an end. That end is an integrated supply chain strategy that supports the business strategy. Inventory is part of that whole. It is often naively and myopically viewed in isolation from the other elements of a supply chain.

Inventory should work synergistically with customer service, supply, transportation, and warehousing to constitute a supply chain and the logistics within it. Those interdependencies must be understood and modeled to optimize a supply chain strategy and the inventory levels required to support it. This chapter discusses those interdependencies and models. We begin by defining the terms *logistics, supply chain*, and *supply chain logistics*.

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4.1 INVENTORY AND LOGISTICS

There are many definitions of logistics circulating in the world of supply chain management, almost as many as there are supply chains. We developed a simple definition over 20 years ago: *logistics is the flow of material, information, and money between consumers and suppliers*.

Unpacking that simple sentence teaches the foundation of supply chain logistics. First, logistics is *flow*. Flow is a good thing. What happens to water when it stops flowing? Stagnation, scum, insects, and possibly death. What happens to blood when it stops flowing? The nerds in the group always say, "Coagulation." The nonnerds usually just say, "Somebody dies." The point is that when material, information, and money stop flowing, some elements of the business and supply chain become unhealthy and may die. Even the highest-performing professionals may lose their jobs when those flows stop. Customers and shareholders become disgruntled when those flows stop. Flow is a good thing.

Second, material, information, and money should flow *simultaneously, in real time, and without paper*.

Third, logistics flow should be viewed, considered, and modeled bidirectionally, "between consumers and suppliers." Otherwise, its design will be suboptimal.

We can also learn about logistics from its root, *logic*. According to the dictionary, *logic* means "reason or sound judgment." Unfortunately, reason and sound judgment are missing from many logistics and inventory decisions and often fall prey to the tyranny of self-imposed deadlines and/or prevailing fads and philosophies. Ironically, logic has gone missing from a lot of logistics.

Supply Chain If that is logistics, what is a supply chain? There seems to be just as much confusion about the definition of a supply chain as there is about that of logistics. Everyone seems to have his or her own. Here is ours: *a supply chain is the infrastructure of factories, warehouses, ports,*

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highways, railways, terminals, modes of transportation, and information systems connecting consumers and suppliers.

Supply Chain Logistics Putting the two elements together, supply chain logistics is the flow of material, information, and money in the infrastructure of factories, warehouses, ports, information systems, highways, railways, terminals, and modes of transportation connecting consumers and suppliers. Logistics is what happens in the supply chain. Logistics activities (customer response, inventory management, supply, transportation, and warehousing) connect and activate the objects in the supply chain. I like to use a sports analogy: the supply chain is the stadium, and logistics is the game.

Supply Chain Logistics Activities In 1990 I developed Frazelle's Framework of supply chain logistics to help professionals understand and implement supply chain strategies. The framework is guiding the supply chains of many of the world's largest supply chain organizations and is the foundation for the supply chain curricula of many academic programs.

Our framework is the answer to a desperate prayer for a means to explain to a mean-spirited, cynical CEO of a very large chemical company why he did not need the $15 million warehouse and hundreds of jobs he had just promised on TV to a downtrodden local economy. I needed a way to explain that a large warehouse was not the best answer to the absence of a customer service policy, excess inventory, disintegrated sources of supply, and uncoordinated transportation operations. The answer was to eliminate or minimize the need for physical warehousing by (1) developing a *customer service* policy, (2) determining the amount of *inventory* required to support that policy, (3) optimizing and coordinating the *supply* and manufacturing schedules, and (4) optimizing the *transportation* operations. Whatever role remained for physical inventory (5) defined the requirements for *warehousing*. Once that supply chain strategy was developed, the excess inventory and the need for additional warehousing were eliminated, customer service improved, and profits increased.

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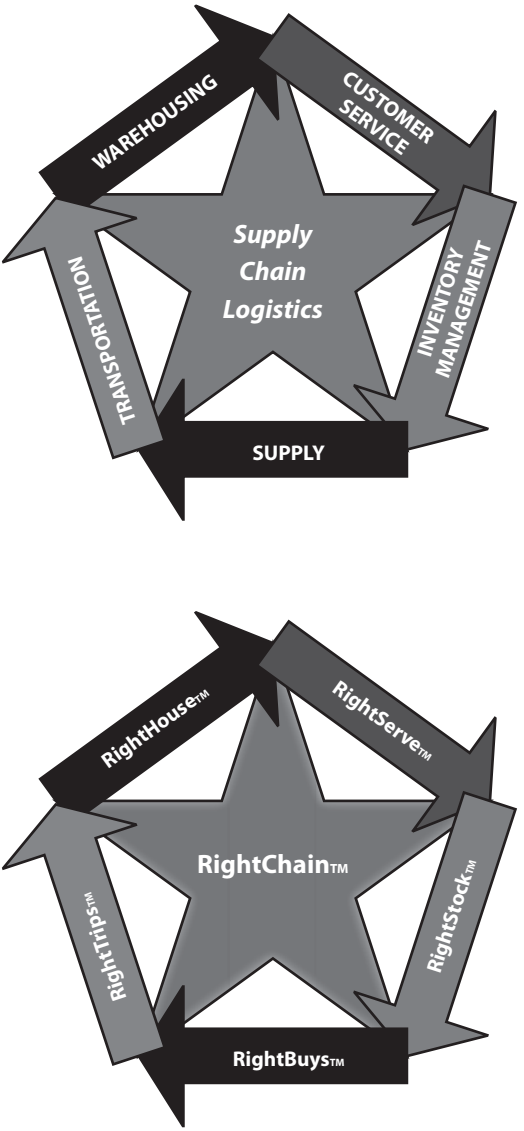
Thus emerged our five-pointed star model (Figure 4.1) of supply chain logistics: the sequential activities of customer service, inventory management,

Figure 4.1 RightChain Model of Supply Chain Logistics



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supply, transportation, and warehousing. Each element individually and in conjunction with the others ultimately determines inventory requirements. We will consider them one by one and then in conjunction with one another.

Our RightChain framework goes one level deeper in explaining the activities of supply chain logistics. That level is presented in Figures 4.2 and 4.3.

According to our RightChain model, customer service optimization (RightServe™) is accomplished through customer valuation, segmentation, and optimization (RightSales™); SKU valuation, segmentation, and optimization (RightSKUs); pricing optimization (RightPrice™); customer satisfaction optimization (RightSat™); and customer service policy optimization (RightTerms™).

Inventory optimization (RightStock) is accomplished through forecast optimization (RightCast), lot size optimization (RightLots), fill rate

Figure 4.2 Frazelle's Framework of Supply Chain Logistics: Descriptive

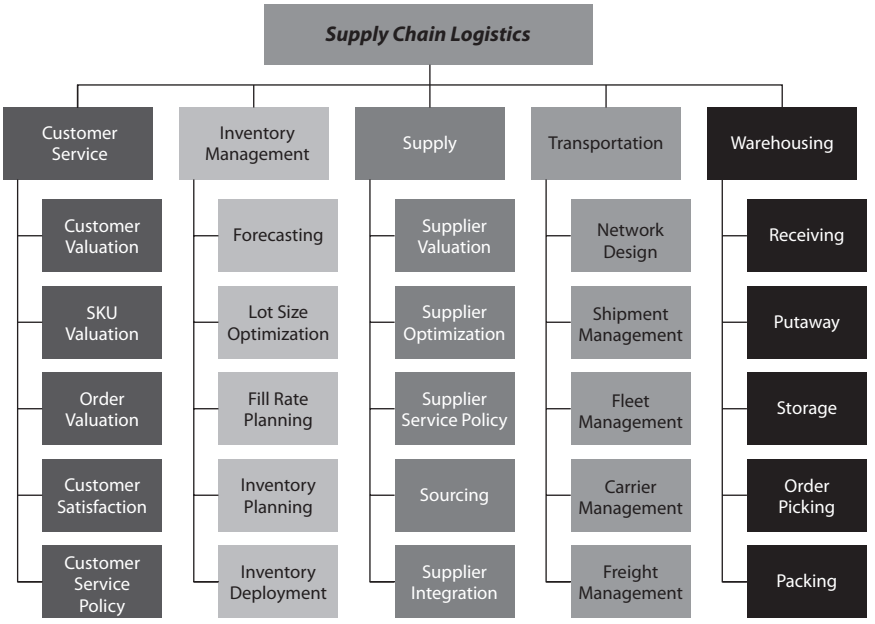

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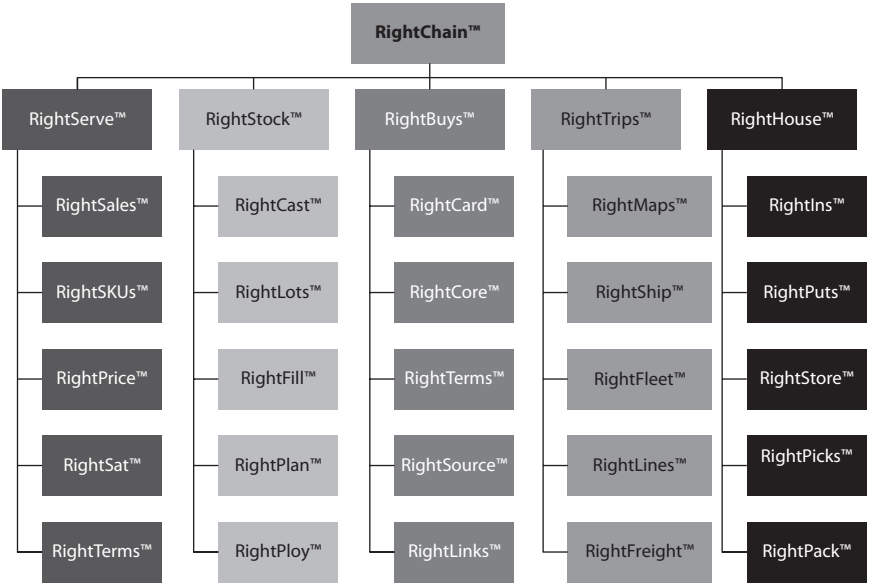
Figure 4.3 RightChain Framework of Supply Chain Logistics



optimization (RightFill™), inventory planning optimization (RightPlan™), and inventory deployment optimization (RightPloy).

Supply optimization (RightBuys™) is accomplished through supplier valuation (RightCard™), supplier optimization (RightCore™), supplier service policy optimization (RightTerms), allocation optimization (RightSource™), and supplier integration (RightLinks™).

Transportation optimization (RightTrips™) is accomplished through network optimization (RightMaps™), shipment optimization (RightShip™), fleet optimization (RightFleet™), carrier optimization (RightLines™), and freight optimization (RightFreight™).

Warehouse optimization (RightHouse™) is accomplished through receiving optimization (RightIns™), putaway optimization (RightPuts™), storage optimization (RightStore™), order picking optimization (RightPick™), and packing optimization (RightPack™).

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Each of these subactivities also has a major impact on inventory requirements, which we will consider as well.

4.2 INVENTORY AND CUSTOMER SERVICE

Our RightChain model begins with customer service for two reasons. First, a humble attitude of service is part of the basis for supply chain success. High levels of customer service are a common denominator in superior supply chain leadership. Quite simply, *leaders serve*. Second, the constraints developed as part of a customer service policy are the underpinnings for supply chain and inventory optimization.

It is fascinating to observe the faces and body language of managers and directors in RightChain kickoff meetings. The bodily and facial slumping sets in almost immediately. Most of the participants assume that the project will be all about cutting heads and heavy expense reductions through declining service offerings. That's not what RightChain and RightStock are about. They and we are about determining *the most profitable method and level of inventory to service customers and take the burden of supply chain logistics off sales and marketing so that they can focus on sales and marketing*. In the end, our strongest proponents are often sales and marketing teams, dealer support groups in automotive service parts, chefs in restaurant projects, and doctors in healthcare programs. RightChain begins with service.

Customer service and customer service policies link supply chain logistics externally to the customer base and internally to sales and marketing. Customer service is optimized when the customer service policy (CSP) that maximizes the financial and service performance of the organization is identified, implemented, and maintained.

Optimizing customer service (RightServe) includes customer valuation, segmentation, and optimization (RightSales); SKU valuation, segmentation, and optimization (RightSKUs); pricing optimization (RightPrice); customer satisfaction optimization (RightSat); and customer service policy

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optimization (RightTerms), all of which play a major role in determining inventory requirements.

A customer service policy developed as part of a supply chain and inventory strategy project for a major semiconductor manufacturer is shown in Figure 4.4. The figure illustrates many of the dimensions of a customer service policy that affect inventory requirements, including fill rate, response time, returns, value-added services, minimum order quantities, and consolidation. Among those, fill rate and response time nearly always have the greatest impact on inventory requirements.

Inventory and Fill Rate Fill rate requirements go a long way toward determining overall inventory requirements. Simply put, all things being equal, the higher the fill rate requirement, the higher the inventory level required to support it. The higher inventory levels are a result of additional safety stock inventory.

An inventory and fill rate analysis from a recent engagement of ours in the health and beauty industry is shown in Figure 4.5. Note that as the fill rate increases (from 50% to 99.95%), the required inventory investment increases accordingly from $4,646,094 to $8,644,548. At the same time, lost

Figure 4.4 Customer Service Policy for a Semiconductor Company

Service Segment	Customer-Item Class	Fill Rate	Response Time (Hours)	Returns Policy	Value Added Services	Minimum Order Quantity	Consolidation
I	A-A	99.0%	24	100%	Custom	None	Custom
II	A-B	95%	24	100%	Custom	None	Custom
III	A-C	85%	48	100%	Custom	None	Custom
IV	B-A	97%	24	50%	Limited	1000+	Partial
V	B-B	90%	48	50%	Limited	500+	Partial
VI	B-C	80%	72	0%	None	100+	Partial
VII	C-A	90%	48	50%	None	5000+	Partial
VIII	C-B	75%	72	0%	None	1000+	Partial
IX	C-C	50%	96	0%	None	500+	Partial

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sales cost declines from a high of $17,953,234 at a 50% fill rate to a low of $17,953 at a 99.95% fill rate.

The current inventory investment in this example was $8,300,000, and the lost sales cost was $3,949,712. The inventory investment that should have achieved a 99.9% fill rate yielded only an 87% fill rate. The discrepancy turned out to be a major misdeployment of inventory.

Inventory and Response Time Customer response time requirements are also a significant contributor to inventory requirements. If required customer response times are longer than supplier and/or manufacturing lead times, no inventory is required. If that is not the case, the shorter the response time requirement, the greater the inventory requirement. The increase normally is due to additional facilities required in close proximity to customers and their associated inventory deployment requirements. The greater the number of inventory stocking locations, the greater the inventory requirements.

Inventory and Delivery Frequency Delivery frequency is an important but often overlooked dimension of customer service policy. In general, more frequent deliveries produce better customer service and lower inventory levels. Delivery frequencies also determine lot sizes. Daily shipping equates to a daily lot size; weekly shipping equates to a seven-day lot size. The greater the lot size, the greater the inventory. More frequent deliveries generate higher transportation costs, a result of more frequent trip setups and greater travel distances.

Delivery frequency optimization (DFO) determines the delivery frequency—days between deliveries—that minimizes total logistics cost, including transportation and inventory carrying cost. A delivery frequency optimization devised for a large retail client is shown in Figure 4.6. Note that the greater the delivery frequency is, the less inventory and retail space is required to support the delivery policy. For this store location the optimal delivery frequency is three days between deliveries. The optimal solution is

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based on the store's daily sales, inventory density, distance from the warehouse, delivery cost per mile, and setup cost per delivery.

4.3 INVENTORY AND INVENTORY

The second consideration in RightChain supply chain strategy development is inventory planning and management. Many people assume that the goal is to minimize the amount of inventory in the supply chain, but that is not correct. The goal is to *determine the amount and mix of inventory that satisfies the requirements of the customer service policy and maximizes the financial performance of the supply* chain.

4.4 INVENTORY AND SUPPLY

The third set of RightChain decisions operates in the area of supply. Supply is the process of producing or acquiring inventory that is sufficient to meet the targets established in inventory planning. The objective of supply management is to maximize the financial performance of production and/or acquisition while meeting the availability, response time, and quality requirements stipulated in the customer service policy and the inventory strategy. Since we have to make up gaps between supplier service and customer service with excess inventory and/or excess transportation costs, we need high-performance suppliers who have the same (or greater) passion for customer service that we do.

Optimizing supply (RightBuys) includes supplier valuation (RightCard), supplier optimization (RightCore), supplier service policy (RightTerms), sourcing (RightSource), and supplier integration (RightLinks). Those activities and their related decisions have a major impact on inventory requirements.

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Inefficient and unreliable suppliers with unpredictable lead times require us to carry excess inventory to cover their unreliability. Efficient and reliable suppliers who supply fast-moving items with predictable demand allow us to take advantage of inventory reduction strategies such as cross-docking and nonstop putaway.

Among all the supply-based decisions, sourcing—the allocation of business to suppliers and the related choice of purchasing terms—has the greatest impact on inventory. Unfortunately, among all the groups working in supply chain management, the sourcing and procurement organization is the least likely to be trained in inventory and supply chain management. To help make the connection for one client, I recommended that sourcing and procurement move from its posh offices at headquarters to a set of cubicles in the warehouse overlooking the receiving dock. The move was highly unpopular but highly effective. The people making the decisions could literally see and sometimes hear and feel the impact of their decisions.

We also help make the sourcing and inventory connection with sourcing optimizations that take into consideration the full set of parameters and buying terms that affect the financial, service, operations, and inventory performance of the buy. A RightBuys sourcing optimization is shown in Figure 4.7.

This example is from a recent supply chain strategy project in which the client was considering moving a large portion of its supply base to China and Eastern Europe. In fact, the far-sourcing train had a lot of momentum when we were asked to help the company consider the full supply chain ramifications of the decision.

As we typically do, we put each of the company's SKUs through our RightBuys sourcing optimization system. The optimization revealed that about one-third of the SKUs needed to remain domestically sourced, about one-third should be sourced in China, and the remaining one-third could be sourced in Eastern Europe.

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Initial Unit Cost (First Cost) Our analysis considers the three main cost elements of sourcing decisions. The first is the *initial unit cost* (sometimes referred to as the first cost) offered by each supplier. Those costs ranged from $4,101 per unit from the Eastern European candidate to $6,906 per unit from the incumbent domestic suppler.

Landing Costs The second group of costs are *landing costs,* which include inbound freight, customs brokerage, freight forwarding, export compliance, sourcing organization fees, duties, banking fees, and the cost of poor quality. In this case the unit landing costs ranged from $146 per unit with the incumbent domestic supplier to $998 per unit with the Chinese supplier. The sum of unit landing cost and initial unit cost is the *unit landed cost,* which in this case ranged from $4,628 to $6,914.

Inventory Carrying Costs The third set of costs is *inventory carrying costs*. Some sourcing analyses consider landing cost implications, but few incorporate inventory carrying cost. We include the three buckets of inventory described earlier: safety stock, lot size, and pipeline inventory. As we expected, inventory carrying costs from the international suppliers are much higher. The inventory carrying costs for each option range from $11,005 from a candidate domestic supplier to $20,246 from the Eastern European supplier.

Total Cost of Acquisition The sum of inventory carrying cost and landing cost is the *total cost of acquisition,* which in this case ranges from $1,408,646 to $2,085,405. The unit cost of acquisition ranges from $4,695 from the Eastern European supplier to $6,951 from the domestic incumbent.

It is rare for one sourcing option to dominate the evaluation criteria, but that was the case here. The Eastern European option provided the lowest total

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acquisition cost, the highest projected margin, the highest return on sales, the highest inventory value added, and the shortest payback.

4.5 INVENTORY AND TRANSPORTATION

The fourth set of RightChain decisions take place in the area of transportation. The goal of transportation is to link sources of supply with customers within the guidelines of the customer service policy and achieve the best possible financial performance. In that way, transportation is an integral part of a supply chain strategy. Transportation is not merely a non-value-added inconsequential expense line item whose manager's sole focus is to reduce expenses to the bare bones through hard-core carrier negotiations.

Transportation and the CFO A few years ago we worked with a large frozen food company. A group of us were in the executive board room waiting for the CEO to show up for a meeting. I was seated next to the CFO. While we were waiting, he decided to take me through the company's financial statements. He was especially proud of the expense statement for the prior 12 months. He insisted on showing me that all but one of their expense items had been reduced compared with the prior year. He indignantly pointed out that the single line item that had increased in comparison to the prior year was transportation. (I think he thought I was single-handedly responsible for that increase because I was a supply chain consultant.)

He then asked me what I thought they should do about their transportation expenses. Instead of replying right away, I asked him what had happened to profit during the period in which transportation expenses

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had increased. He said that profit was up. I asked him what had happened to market share during the period in which transportation expenses had increased. He said that market share was up. I asked him what had happened to customer satisfaction during the period in which transportation expenses had increased. He said that customer satisfaction had increased. He then got upset and impatiently asked, "But Dr. Frazelle, what should we do about transportation expenses? They are increasing." I said, "It looks to me like you should spend even more on transportation, because it seems to be working." That was the last time he spoke to me. Six months later it was the last time he spoke to anyone in the company because he was let go. I expect that happened because he was overly determined to reduce every single expense in the company even at the cost of lower profits, lower revenue, and poor capital utilization.

Before he was let go, this CFO tried to push his expense reduction point with my partner. The CFO was insisting that we help the company reduce transportation expenses by 20%. To get our point across and show how ridiculous the CFO had become, my partner said to him, "Just transport the orders 80% of the way to the customer. Drop the product off one exit before the customer's exit. Call them and let them know they can pick up the product there."

It's not just about the expenses. Transportation is a key component in an overall supply chain strategy. That strategy exists to maximize the financial and service performance of the company.

Transportation optimization (RightTrips) includes network optimization (RightMaps), shipment optimization (RightShip), fleet optimization (RightFleet), carrier optimization (RightLines), and freight optimization (RightFreight).

Those transportation activities and their related decisions have a significant impact on inventory requirements. We consider two of them in detail here.

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Inventory and Network Design Supply chain inventory levels logically increase as the number of stocking locations in the network increases. The increase is a result of the greater number of deployment decisions, the associated errors, and the resulting additional safety stock.

A supply chain network optimization for a biotechnology client is shown in Figure 4.8. Note that as the number of facilities increases, inventory carrying cost increases. However, total transportation cost decreases. The sum of those two—the total logistics cost—is minimized with four facilities.

Inventory and Shipping Frequency Inventory levels logically decrease as shipping frequency increases. Shipping frequency determines lot size. Daily shipping requires a daily lot size. However, daily shipping requires a daily trip and preparation for that trip. Weekly shipping requires a weekly lot size. However, weekly shipping requires one trip a week instead of seven. A shipping frequency optimization for retail delivery is shown in Figure 4.9.

A summary analysis for all the stores is presented in Figure 4.10. Note that the optimal shipping frequency is greater for the stores that have higher sales rates and are in closer proximity to the distribution center.

Inventory and Modes of Transportation Choosing transportation modes also plays a significant role in determining inventory requirements. The slower the transportation mode, the longer the lead time, the greater the pipeline inventory and associated safety stock inventory, and the higher the inventory carrying costs. However, the slower the mode, the lower the transportation costs. Shipments with high value relative to their weight and cube are best shipped with faster transportation modes, and shipments with low value relative to their weight and cube are best shipped with slower, less expensive modes.

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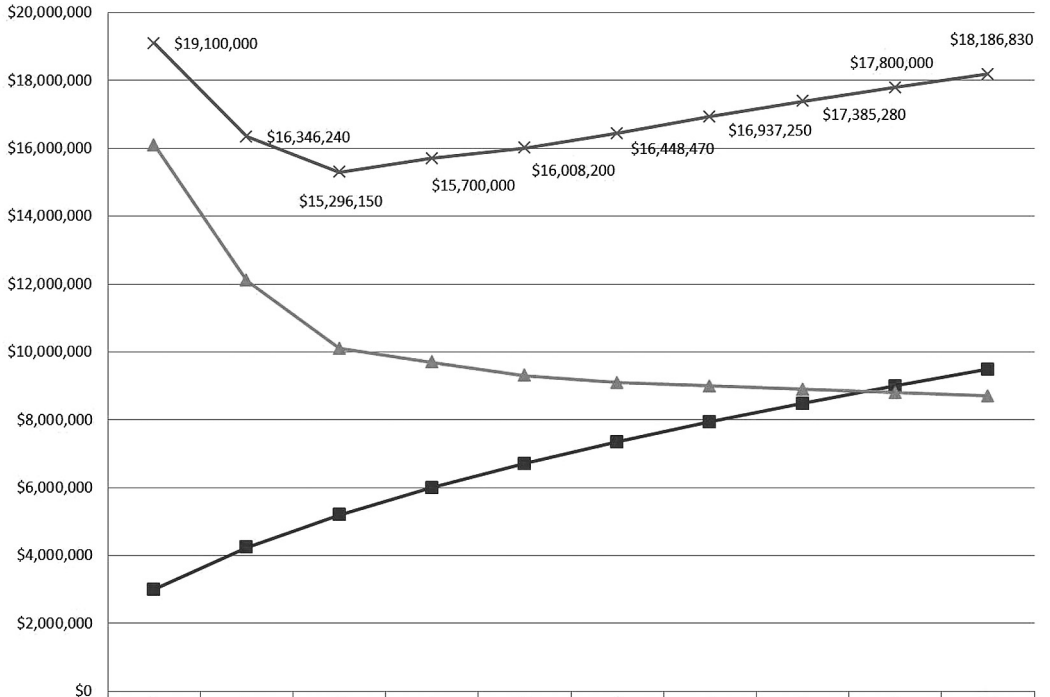
Figure 4.8 Inventory Investment and Supply Chain Network Design



	1	2	3	4	5	6	7	8	9	10
Inventory Carrying Cost	$3,000,000	$4,246,240	$5,196,150	$6,000,000	$6,708,200	$7,348,470	$7,937,250	$8,485,280	$9,000,000	$9,486,830
Total Transportation Cost	$16,100,000	$12,100,000	$10,100,000	$9,700,000	$9,300,000	$9,100,000	$9,000,000	$8,900,000	$8,800,000	$8,700,000
Total Logistics Cost	$19,100,000	$16,346,240	$15,296,150	$15,700,000	$16,008,200	$16,448,470	$16,937,250	$17,385,280	$17,800,000	$18,186,830

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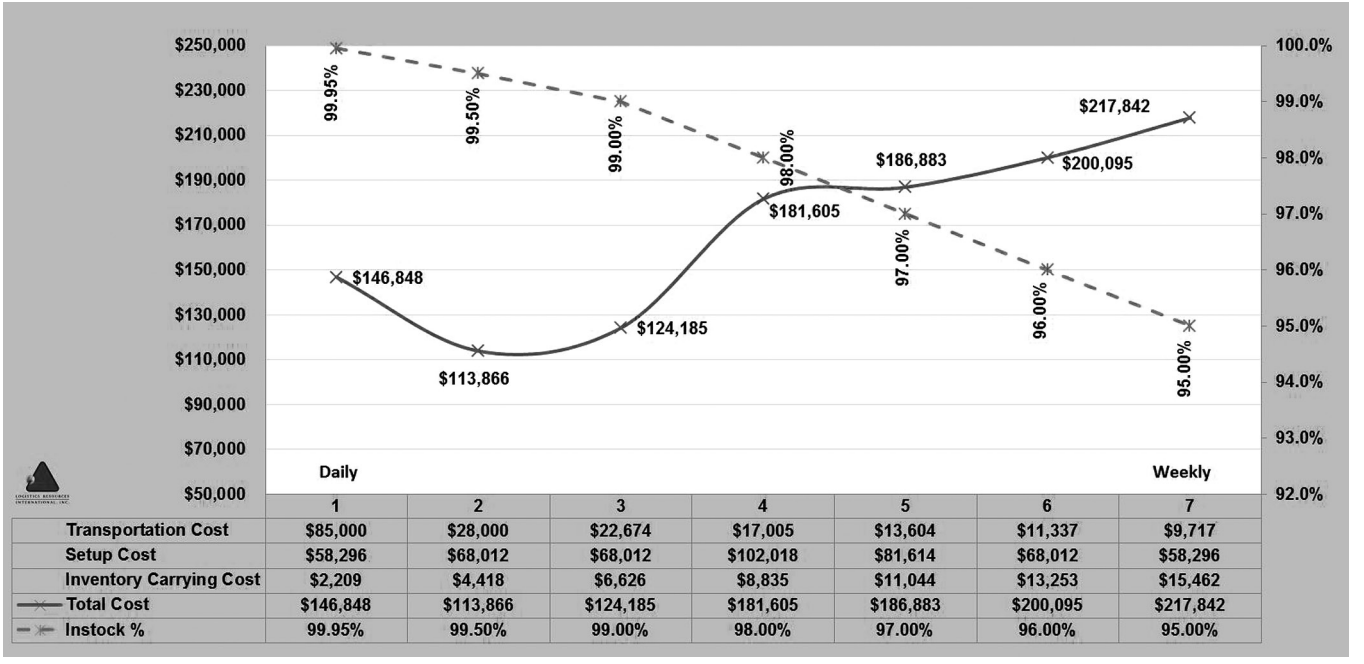
Figure 4.9 Inventory and Shipping Frequency



	1	2	3	4	5	6	7
Transportation Cost	$85,000	$28,000	$22,674	$17,005	$13,604	$11,337	$9,717
Setup Cost	$58,296	$68,012	$68,012	$102,018	$81,614	$68,012	$58,296
Inventory Carrying Cost	$2,209	$4,418	$6,626	$8,835	$11,044	$13,253	$15,462
Total Cost	$146,848	$113,866	$124,185	$181,605	$186,883	$200,095	$217,842
Instock %	99.95%	99.50%	99.00%	98.00%	97.00%	96.00%	95.00%

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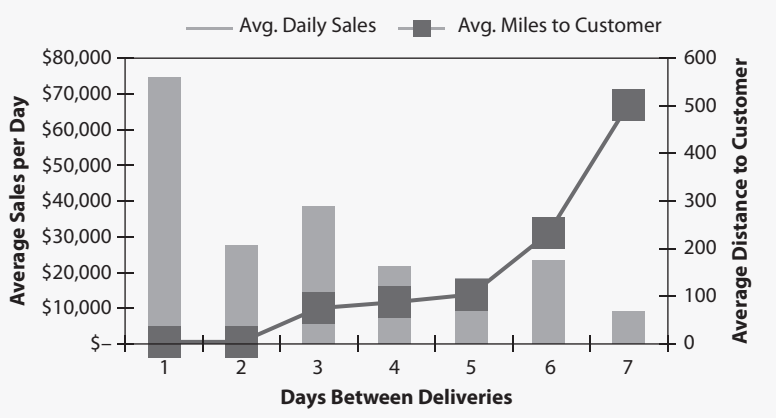
Figure 4.10 Shipping Frequency Optimization Summary

RightServe™ Delivery Frequency Optimization System

Days Between Deliveries	% of Customers	Avg. Daily Sales	Avg. Miles to Customer	Avg. Total Logistics Cost
1	3.0%	$ 75,000.00	2.0	$ 84,070.00
2	3.0%	$ 28,000.00	2.0	$ 70,210.00
3	9.1%	$ 38,000.00	72.3	$ 161,824.44
4	9.1%	$ 21,000.00	86.7	$ 130,491.67
5	21.2%	$ 17,000.00	104.3	$ 127,821.43
6	9.1%	$ 23,666.67	231.0	$ 220,293.33
7	45.5%	$ 9,090.60	500.5	$ 255,359.17



Mode optimization with RightModes™ identifies the transport mode that meets the response time requirements and produces the best financial performance. A mode optimization conducted for a major health and beauty company is shown in Figure 4.11. As expected, the inventory carrying cost for the two air carriers is significantly lower and the freight costs are significantly higher. The optimal mode choice depends on the preferred financial performance metric. In this case, Ocean Carrier 5 minimizes the total logistics cost and the supply chain value added. Air Carrier 1 maximizes gross margin return on inventory and inventory value added.

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Figure 4.11 Inventory and Modes of Transportation

LRI's RightModes™ Mode Optimization System™

Product Parameters	Unit Inventory Value	Unit Selling Price	Inventory Carrying Rate	Forecast Annual Demand	Fill Rate	Leadtime Forecast Error	Weight (pounds)
	$ 4,000.00	$ 7,000.00	35%	2,400	95.00%	45.00%	12

Mode/Carrier Parameters	Air Carrier 1	Air Carrier 2	Ocean Carrier 1	Ocean Carrier 2	Ocean Carrier 3	Ocean Carrier 4	Ocean Carrier 5
Transit Times Door-to-Door	7	12	28	35	30	21	21
Frequency of Shipment Arrival	7	5	7	28	14	21	21
Freight Cost Door-to-Door ($/pound)	$ 25.00	$ 20.00	$ 14.00	$ 11.00	$ 10.50	$ 11.50	$ 11.50
Transportation Setup Cost ($/shipment)	$ 1,200.00	$ 1,500.00	$ 3,000.00	$ 3,600.00	$ 2,400.00	$ 3,800.00	$ 1,900.00
On-Time Arrival Percentage	95.00%	93.00%	94.00%	90.00%	92.00%	94.50%	87.50%
Tardiness (days)	0.50	0.30	4.00	6.30	7.30	8.30	9.30
Inventory Carrying Cost	$ 156,508	$ 235,879	$ 530,663	$ 754,969	$ 601,494	$ 473,036	$ 479,535
Lost Sales Cost	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000
Total Freight Cost	$ 720,000	$ 576,000	$ 403,200	$ 316,800	$ 302,400	$ 331,200	$ 331,200
Transportation Setup Cost	$ 62,571	$ 109,500	$ 156,429	$ 46,929	$ 62,571	$ 66,048	$ 33,024
Total Logistics Cost	***$ 1,299,079***	***$ 1,281,379***	***$ 1,450,292***	***$ 1,478,698***	***$ 1,326,466***	***$ 1,230,283***	***$ 1,203,759***
TLC per Unit	***$ 541.28***	***$ 533.91***	***$ 604.29***	***$ 616.12***	***$ 552.69***	***$ 512.62***	***$ 501.57***
GMROI	***1610%***	***1068%***	***475%***	***334%***	***419%***	***533%***	***526%***
LGMROI™	***1320%***	***878%***	***379%***	***265%***	***342%***	***442%***	***438%***
Inventory Value Added™	***$ 7,043,492***	***$ 6,964,121***	***$ 6,669,337***	***$ 6,445,031***	***$ 6,598,506***	***$ 6,726,964***	***$ 6,720,465***
Supply Chain Value Added™	***$ 5,540,921***	***$ 5,558,621***	***$ 5,389,708***	***$ 5,361,302***	***$ 5,513,534***	***$ 5,609,717***	***$ 5,636,241***

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4.6 INVENTORY AND WAREHOUSING

The fifth and last set of RightChain supply chain strategy decisions has to do with warehousing. It's my personal favorite, but I have to admit that it's the last logistics activity that should be considered in developing a supply chain strategy. First, a clever trip through the first four RightChain initiatives may eliminate, should minimize, and will correctly determine the need for warehousing as opposed to letting the warehouse play its habitual role as the physical manifestation of the lack of supply chain coordination, integration, and planning. Second, the warehouse is like a goalie in a soccer game. Like it or not, it's the last line of defense and needs to be designed accordingly. Third, we need customer service, inventory management, supply, and transportation requirements from the supply chain to properly plan and operate the warehouse.

Optimizing warehousing includes optimizing receiving (RightIns), putaway (RightPuts), storage (RightStore), order picking (RightPick), and packing (RightPack). Those five elements individually and in conjunction play a major role in determining supply chain inventory requirements.

Inventory and Receiving One of the principal ways receiving and putaway affect inventory requirements is via dock-to-stock time, the elapsed time from when an order receipt arrives on the premises until it is ready for picking and shipping. A few years ago we were asked to assist a large apparel retailer with its supply chain strategy. We toured its main distribution center during one of the initial visits. I noticed that the receiving dock looked especially full and asked what the company's dock-to-stock time was. They stated proudly that it was 96 hours. I shared from our benchmarking that 24 hours was the norm, 8 hours was a top quartile result, and 2 hours was world-class. They were defensive and said that they had looked into systems to reduce dock-to-stock time but could never produce an acceptable return on investment. I asked them how much inventory was sitting on the dock.

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It was $8 million worth of inventory. I asked them what range of investment proposals they received for the material handling systems required to help them reduce cycle time to 24 hours. Quotes were in the range of $2 million. I did some quick math and calculated that by reducing their dock-to-stock time by 75% they could reduce their inventory by $6 million. I asked them, "Wouldn't it make sense to spend $2 million to take $6 million out of inventory or to reduce inventory carrying costs by $2 million per year at a 33% inventory carrying rate?" They said that they had tried to compute a return on investment (ROI) that was based on labor savings alone and had not considered inventory savings. That reconsideration launched one of the nation's most successful supply chain strategies.

Inventory and Storage Two features of storage have a major impact on inventory levels: inventory accuracy and storage space utilization.

High levels of inventory accuracy are achieved through high putaway and picking accuracy, ABC cycle counting, disciplined housekeeping, and real-time transactions. Without high degrees of trust in the numbers used to support this accuracy, inventory and supply chain planning break down quickly.

Optimal storage utilization helps enforce healthy inventory management. In our early work with Honda, that company's warehouse space utilization was in excess of 98%. When it came time to implement a new warehouse management system, the warehouses were so full that there was no room to move product to create the space needed to relabel and reconfigure racking to accommodate the new system. I suggested that they delay implementation and reset the storage utilization capacities to 85%, which is what it should be for most warehouses. They asked me what they would do with their excess inventory. I half jokingly suggested that they rent a warehouse in a remote location where space was especially cheap. Any product occupying space over and above 85% should be shipped to that remote location. When the 85% occupancy had been established, they could install the warehouse management system.

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I was a bit surprised to learn later that they had accepted my recommendation. The remote warehouse occupied more than 500,000 square feet. The Japanese president received the monthly bill and dispatched an associate to look at the remote operation. It turned out the material was essentially excess safety stock generated by the forecasting system. The excess had previously been stuffed into the company's facing distribution centers. Pulling the material out of the forward DCs helped them see and experience just how much excess safety stock their inventory plan was producing. The visualization and the bill from the third party helped motivate a highly successful makeover of their forecasting process and system.

Summary Space and time do not permit us to discuss all the facets of supply chain logistics and their impact on inventory. A summary of the factors we have discussed and their impact on inventory is presented in Figure 4.12.

These supply chain principles are like logistics laws of gravity; they just are. To think otherwise is to live in supply chain denial.

Several years ago one of our clients retained us to help it with a space dilemma. The distribution group was running overtime, working at 106% occupancy in its main DCs, and renting five off-site overflow DCs. The CFO was peeved by the overages. The company's distribution group complained that they were allocated only enough space to accommodate the inventory levels projected by their merchandising group, whose sales and turn forecast projected that there was sufficient space.

We were invited to help resolve the conflict. We found that the merchandising group had jury-rigged the inventory turn forecasts. Regardless of true trends in sales or turns, their projection always suggested that the current space was adequate. They simply took the true sales forecast and forecast the turns required to avoid renting outside space. They never met those turn rates.

To help resolve the issue I took the inventory requirements factors we just discussed—the fill rate, the number of SKUs, forecast accuracy, and so

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Figure 4.12 Tying It All Together

Factor	More inventory is required if…
Fill Rate	Fill rate requirements are **higher**
Response Time	Response time requirement is **shorter**
Shipping Frequency	Shipping is **less frequent**
Return Rates	Return rates are **higher**
SKUs	There are **more SKUs**
Forecast Accuracy	Forecasting is **less accurate**
Lead Time	Lead times are **longer**
Lot Size	Lot sizes are **larger**
Deployment	**More stocking locations** are utilized
Visibility	Visibility is **poorer**
Transportation Mode	Modes are **slower**
Loss and Damage	Loss and damage are **higher**
Inventory Accuracy	Inventory accuracy is **poorer**

on—and taught a short seminar for both groups on the impact each factor would have on inventory. Once they all agreed on the factors in principle, I took them through their particular trends. Fill rate requirements were higher. Forecast accuracy was lower. Lead times were longer. There were many more SKUs. Supply chain visibility was poorer. After a few minutes the head of

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merchandising made me stop. He admitted that they had gotten the point. The business unit president insisted that I go on. It was very awkward, but she insisted that I finish the presentation revealing that every single one of their supply chain trends suggested that they would continue to need even more inventory and space than they already had. Basically, the head of merchandising had been caught red-handed manipulating the turn forecast.

4.7 INVENTORY AND THE SUPPLY CHAIN

A recent client requested that we develop the wrong chain model (Figure 4.13) to help them understand the self-inflicted suboptimization, internal conflict, and excess inventory in their supply chain. This also happens to be the reason why there is self-inflicted suboptimization, internal conflict, and excess inventory in nearly every supply chain.

Think about a typical supply chain including sales, manufacturing, sourcing, transportation, and warehousing.

First stop, sales. Let's assume that the sales force creates the forecast and works on commission. What is the worst thing that could happen to a commission salesperson? Running out of product. So guess what kind of forecast sales will most likely turn in. You got it: an inflated forecast that will not run out of product. The result: more safety stock inventory than you know what to do with.

Second stop, manufacturing. How are most plant managers evaluated? The large majority of plant managers are evaluated on the basis of unit cost, plant yield, and/or machine utilization within the four walls of the plant. How does one go about achieving those objectives? Long production runs creating lots of inventory are the norm.

Third stop, sourcing. How are most buyers measured? The large majority of buyers are measured on the basis of how low a price they can pay a vendor for the product. How does one get a low price? Large purchase quantities creating lots of inventory are the norm.

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Figure 4.13 Wrong Chain Model of Supply Chain Suboptimization

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Next stop, transportation. How are most transportation managers measured? Most transportation managers are evaluated on the basis of transportation cost as a percentage of sales, cost per mile, and/or vehicle utilization. How does one minimize transportation cost and maximize vehicle utilization? By making sure the outbound containers and vehicles are as full as possible, in other words by maximizing the in-transit inventory.

Last stop, warehousing. How are most warehouse managers measured? Most warehouse managers are measured on the basis of space utilization and labor cost per unit. How does one maximize space utilization? By filling up the warehouse. How does one minimize the labor cost per unit? By holding orders and releasing large batches of work to the warehouse floor. Those two objectives work together to increase four-wall inventory.

Is it any wonder there is excess inventory in nearly every supply chain?

One day I received a call from the chief operating officer of a large food company. He said that they were struggling with the inventory levels in their supply chain strategy. I asked him if he minded if I guessed what their problem was. I took him through the illogic of what I just exposed. There was an awkward silence on the line, and then he burst out laughing. I asked him why he was laughing. He said it was because they had been struggling with their excess inventory levels for more than a year and had paid millions for unfruitful software licenses and consulting fees and in less than a minute I had diagnosed their inventory ills without ever stepping into one of their offices or operations. He said he thought I was a supply chain genius.

I'm not a genius. What I told him and just shared with you is the root cause of the large majority of inventory ills in every supply chain. The illness is the misalignment of metrics between elements of the supply chain.

There are many and various mistakes in the wrong chain model. Sometimes it's helpful to learn from mistakes.

One mistake is silos of decision making. We correct that mistake in the RightChain Supply Chain Integration Model (Figure 4.14) by housing all supply chain activities under one decision-making roof. Another major mistake in the wrong chain model is the focus on unit cost reduction

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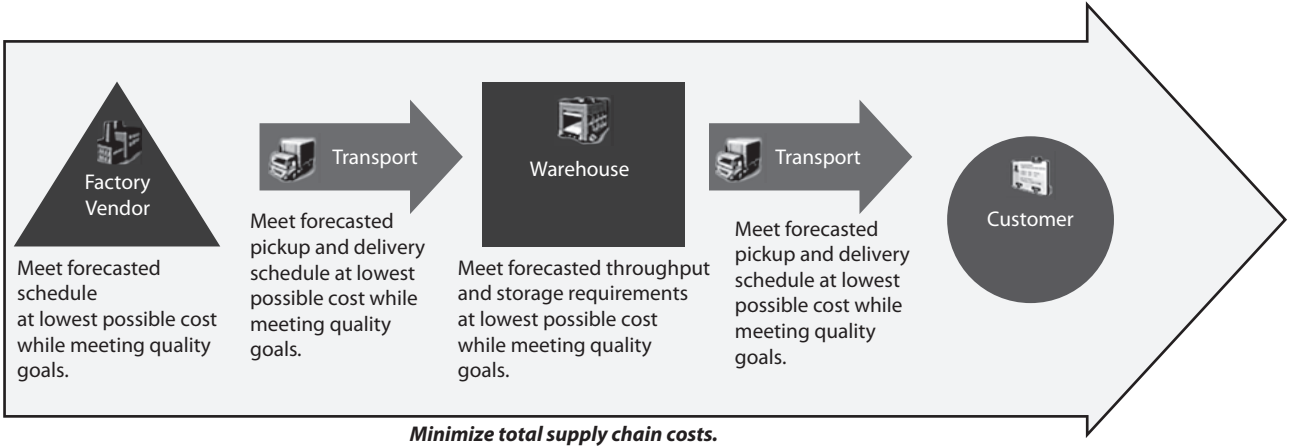
Figure 4.14 RightChain Supply Chain Integration Model



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achieved primarily by maximizing the utilization of individual resources in the supply chain. RightChain corrects that by developing and implementing an overarching objective function to minimize total supply chain cost while simultaneously meeting the requirements of the customer service policy.

Our RightChain Supply Chain Integration Model uses optimization to portray the mission of an integrated supply chain and determine the proper role and schedule for each supply chain activity. The primary role of the contributing activities is to meet the integrated and optimized supply chain schedule. For example, plant managers, who formerly focused almost exclusively on reducing manufacturing unit cost and increasing machine utilization, now focus on schedule attainment: the schedule that is best for the entire chain. Buyers, who formerly focused almost exclusively on "cost avoidance" typically accomplished through large buy commitments from faraway places, now focus on the most profitable buy and inbound product delivery schedule that is best for the entire supply chain. Transportation managers, who formerly focused almost exclusively on squeezing every penny out of carrier negotiations and/or making sure that every container, vehicle, and driver was fully utilized, now focus on making sure the pickup and delivery schedule that is best for the entire supply chain is reliably executed. Warehouse managers, who formerly focused almost exclusively on making sure every slot, vehicle, dock, and operator was fully utilized, now focus on executing the shipping and receiving schedule that is best for the entire supply chain and the operating storage capacity that best accommodates the inventory requirements for the entire supply chain. Sales is now held accountable for the accuracy of its forecasts. *The resulting inventory is the right level of inventory*.

4.8 BEYOND S&OP

Sales and operations planning receives a lot of attention as a potential panacea for inventory optimization and rationalization. When it is done properly, it can help along those lines. The key word is *properly*.

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Over the last few years I have attended, reviewed, and facilitated several S&OP meetings. Sometimes sales is not there. Sometimes operations is not there. Sometimes planning is not there. Sometimes inventory is not discussed. Sometimes logistics is not involved. Sometimes the meeting morphs into a seminar. Sometimes the meeting doesn't happen. Reliable data is the exception rather than the rule. The decision support tools necessary to answer tough questions are rarely available. Though it is seemingly a standard in the industry, I have found S&OP to have as many different meanings as there are companies.

Despite those disappointments, I was encouraged recently at two client sites. Pratt & Whitney Canada coined the term *SIOP* for "sales, inventory, and operations planning," and Coca-Cola Consolidated coined the term *T&OP* for "transportation and operations planning." They both recognized that something is missing from S&OP and attacked the problem on their own.

As I mentioned earlier, there are a variety of valid perspectives on inventory: (1) financial, service, and operations, (2) strategic, tactical, and execution, and (3) customer service, manufacturing, sourcing, transportation, and warehousing. Each of those perspectives needs to be addressed, optimized, and rationalized in the S&OP process and meetings. In addition, although traditional S&OP has focused primarily on inventory, the scope should be expanded to consider the total supply chain and its ability to support the financial and service requirements of the business. We developed the RightChain planning process to help companies move beyond S&OP to integrated supply chain planning and optimization. The process is illustrated in Figure 4.15 and described in steps 1 through 7.

1. *Cadence and gates.* Supply chain requirements and capacity must be rationalized and optimized in the short, middle, and long term. Therefore, the RightChain program works in daily (Gate I), weekly (Gate II), monthly (Gate III), quarterly (Gate IV), and annual (Gate V) time frames.

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Figure 4.15 RightChain Planning Process

	Cadence >	**Daily**	**Weekly**	**Monthly**	**Quarterly**	**Annually**
	Time Frame >	**EXECUTION**	**EXECUTION/TACTICAL**	**TACTICAL**	**TACTICAL/STRATEGIC**	**STRATEGIC**
	Participation >	**Manager**	**Manager/Director**	**Director**	**Director/VP**	**Director/VP/C-Level**
	GATE >	I	II	III	IV	V
Demand & Requirements	**Customer Response**	Sales Orders Update Shipping Update MRP/DRP Update	→ Pre-Concensus Forecasting	→ Concensus Forecasting Demand Planning	→ Customer Valuation Customer Satisfaction CSP Update SKU Valuation	→ Long Range Demand Planning Portfolio & Channel Strategy Customer Service Policy Customer Conference
Optimization Rationalization	**Inventory**	Inventory ABC Cycle Count Perpetual Inventory	Management RightChain™ Inventory Scheduling Supply Signal Update	Director RightChain™ Smoothing Concensus Planning Inventory Planning	Executive RightChain™ Deployment Review Material Flow Plan Supply Chain Scoreboard Review	Strategic RightChain™ Network Strategy Flow Strategy Supply Chain Strategy
Supply & Capacity	**Manufacturing** **Supply** **Transportation** **Warehousing**	Production Purchase Orders Bills & Manifests Receipts & Pick Sheets	Manufacturing Scheduling Supply Scheduling Transportation Scheduling Warehouse Scheduling	Manufacturing Planning Supply Planning Transportation Planning Warehouse Planning	Manufacturing Review Sourcing Review Transportation Review Warehouse Review	Long Range Capacity Strategy Sourcing Strategy & Supplier Conference Transportation Strategy & Carrier Conference Warehousing Strategy & 3PL Conference
METRICS	**Finance** **Service** **Inventory** **Stability**	Sales OTD, POP Inventory Accuracy No. of Changes	Sales OTD, POP $s, Days, Turns No. of Changes	EBIT, ROS, Cash, ROIC OTD, POP IVA, GMROI, IPC, $s, Days, Turns % Changes	EBIT, ROS, Cash, ROIC OTD, POP IVA, GMROI, IPC, $s, Days, Turns % Changes	EBIT, ROS, Cash, ROIC OTD, POP IVA, GMROI, IPC, $s, Days, Turns % Changes

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2. *Organization levels.* All levels of the organization are affected by, should participate in, and should be held accountable for RightChain decisions. Participation by levels including manager, director, and executive is highlighted in the figure. Meeting types are labeled as Management RightChains, Director RightChains, and Executive RightChains to reflect the nature of the decisions considered in the work sessions.
3. *Players.* At each gate in the RightChain planning process, appropriate representatives from the major multidisciplinary areas of the corporation should meet. For example, Executive RightChain meetings would include the CFO/VP Finance, COO/VP Operations, CEO/President, CSMO/VP sales and marketing, CMO/VP manufacturing, and CSCO/VP supply chain. Director RightChain meetings would include their counterparts at the director level. Management RightChain meetings would include their counterparts at the management level.
4. *Demand and requirements***.** Forecast demand has typically focused on customer demand in units or dollars and is often developed solely by sales. Customer demand should be vetted through consensus forecasting and should be extrapolated to include all supply chain units of measure, including pieces, cases, pallets, cube, weight, and loads. The elements of the customer service policy, such as fill rate, response time, and delivery frequency, also act as requirements on the supply chain and should be considered as well. All of these are reflected in the swim lane labeled "Demand & Requirements."
5. *Supply and capacity.* Capacity in S&OP has typically focused on unit manufacturing capacity. Capacity should reflect not only manufacturing capacity but also sourcing capacity, transportation capacity, warehousing capacity, I/T capacity, and financial capacity to fund inventory investments. Each of those

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is a potential bottleneck in total supply chain capability. Each potential bottleneck is considered in the "Supply & Capacity" swim lane.

6. *Performance measures.* Traditional S&OP performance metrics are focused on operational inventory indicators such as inventory days on hand or turns. However, a supply chain schedule, plan, and strategy affects many more metrics, including inventory financial performance, EBIT, return on invested capital, workforce productivity, supply chain asset utilization, revenue, total supply chain cost, customer service, and complexity. Our RightChain Scoreboard considers the full range of interrelated metrics (see Figure 4.16). It is organized by metrics related to providing customers with excellent customer service, employees with a great place to work, and shareholders with excellent financial returns.
7. *Tools and data.* One of the typical hindrances to successful S&OP meetings is the lack of real-time decision support tools to answer the tough and sometimes meeting-squelching questions that arise. We developed the RightChain Analytics Portal to support real-time data mining and decision making at each planning stage. A RightChain Analytics Portal home page from a recent client engagement is shown in Figure 4.17.

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