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Mapping the Automotive Textile Supply Chain: The Importance of Information Visibility

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Absract

Information visibility is an essential element to improved supply chain performance. Without adequate sharing of information, firms are required to supplement the available information with other costly alternatives. This paper follows the development of a convertible fabric material in the supply chain for a large automotive assembler, beginning with a large textile manufacturer in fabric formation to final assembly of the convertible top. The current level of information sharing in the supply chain is assessed and the effects of inefficient information flows between the various tiers of suppliers are determined. In order to improve performance in this supply chain and create a truly integrated value systems, a number of tactical and strategic changes will be required throughout the automotive textile supply chain.

Keywords: convertible fabric material, supply chain, automotive textiles

Introduction

Without the buy-in of supply chain members, asking them to react faster in response to real-time ordering systems is an exercise in futility. A supplier who receives an order via the Internet, prints it out, and puts it on a stack on their desk is not contributing to supply chain value. Instead, when information is shared via the supply chain and made available to all parties, such that demand requirements, capacity limitations, inventory positioning, and collaboration between partners is established through a priori agreements, then the power of the Internet can begin to be fully exploited. This means providing an Internet-accessible, real time forum where buyers and their suppliers can communicate and share inventory and forecasting information, and allow for the effective dissemination of engineering change orders (ECOs) throughout the supply chain. Nowhere is this more important than in the automotive supply chain, where textile manufacturers are often several tiers removed from the final OEM assembler, and often subject to the vagaries of poor forecasts and lack of information. We investigate this phenomenon, beginning with a review of the literature on the importance of information visibility in a supply chain and the "bullwhip" effect. Next, we discuss the approach used to map the supply chain, then conclude with some summary observations.

Literature review:

The Importance of Information in supply chains: Avoiding the Sting of the "Bullwhip"

The need to share information across the supply chain is of paramount importance. Less frequently addressed but equally as important is the need to make certain that this information is accurate. In fact, lack of information or distorted information passed from one end of a supply chain to the other can create significant problems, including, but not limited to, excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules. It is doubtful that these are deliberate attempts to sabotage the performance of fellow supply chain members. Rather, distorted information throughout the supply chain is a common result of what logistics executives at Procter and Gamble (P&G) and other organizations have termed the *bullwhip effect.*

The Bullwhip Effect

In the 1990's, P&G, began to explore this phenomenon after a series of particularly erratic shifts in ordering up and down the supply chain for one of its most popular products, Pampers disposable diapers. After determining that it was highly unlikely that the infants and toddlers at the ultimate user level were creating extreme swings in demand for the product, the review team began to work back through the supply chain. It was found that distributors' orders showed far more demand variability than found at the retail stores themselves. Continuing through the supply chain, P&G's orders to its supplier, 3M, indicated the greatest variability of any of the supply chain linkages.[1] Four causes of this phenomenon were identified:

1. Demand forecast updating
2. Order batching
3. Price fluctuations
4. Rationing within the supply chain.[2]

This bullwhip effect is certainly not unique to P&G or even to the consumer packaged-goods industry. Firms from Hewlett-Packard in the computer industry to Bristol-Myers Squibb in the pharmaceutical field have experienced a similar phenomenon. Even a slight to moderate demand uncertainty and variability become magnified when viewed through the eyes of managers at each link in the supply chain. If each manager makes ordering and inventory decisions with an eye to the firm's own interest above those of the chain, stockpiling may be simultaneously occurring at as many as seven or eight places across the supply chain, leading in some cases to as many as 100 days of inventory—waiting. One study projected $30 billion in savings could result from streamlining the order information-sharing process in grocery industry supply chains alone.[3]

Supply Chain Organizational Dynamics

Several interorganizational dynamics come into play when addressing information sharing across the supply chain. Two issues in particular are risk and power. All enterprises participating in a supply chain management initiative accept a specific role to perform. They also share a common belief that they and all the other supply chain participants will be better off because of their collaborative efforts. Each member specializes in the function or area that best aligns with its competencies. Risk occurs in that each firm must now rely on other supply

[1] Lee L. Hau, V. Padmanabhan, and Seungjin Whang, "The Bullwhip Effect in Supply Chains," Sloan Management Review, spring 1997, pp. 93–102.
[2] Ibid.
[3] Ibid.

chain members as well as its own efforts to determine the success of the supply chain. Some supply chain members are more dependent on the supply chain success than others. Thus, members with the most at stake may take more active roles and assume greater responsibility for fostering cooperation, including the information-sharing efforts, throughout the supply chain.

Power within the supply chain is a central issue, one that in today's marketplace centers on information sharing. Although not universal to all industries, there has been a general shift of power from manufacturers to retailers over the last two decades, which has resulted from a combination of factors. One is the trend toward consolidation at the retail level within the supply chain. Gone are the days of "Mom and Pop" grocery stores in every neighborhood or the locally owned, independent hardware store in each town. In the interest of capitalizing on the benefits of economies of scale, giant retail conglomerates operate as part of nationwide supply chains. In fact, relatively few of the thousands of retailers operating in the United States control the majority of dollars in this industry. Clearly, this consolidation impacts the entire supply chain. Fewer and fewer firms control access to consumer trading areas.

Perhaps more importantly, retailers sit in a very important position in terms of information access for the supply chain. For several reasons, major retailers have risen to this position of prominence through technologies such as bar codes and scanners, sheer size and sales volume, and most importantly, their position within the supply chain right next to the final consumer. This combination of factors has put retailers in a very powerful position within the supply chain.

Wal-Mart's and P&G's experiences demonstrate how information sharing can be utilized for mutual advantage. Through state-of-the-art information systems, Wal-Mart shares point-of-sale information from its many retail outlets directly with P&G and other major suppliers. Rather than causing Wal-Mart to lose power within these partnerships, this willingness to share information provides the retailer with a competitive advantage by freeing its resources from many of the tasks associated with managing supplier's products. The product suppliers themselves become responsible for the sales and marketing of their products in the Wal-Mart stores through easy access to information on consumer buying patterns and transactions.[4]

The concepts described above can be applied throughout most supply chains once a degree of trust has been established. In fact, many automobile manufacturers have a goal of mass customization of their line for individual buyers. The goal is to allow a customer to select specific attributes they desire in their new cars, and to have their car delivered within a short period – as little as 2-weeks.

CREATING INFORMATION VISIBILITY IN SUPPLY CHAINS[5]

What is Information Visibility?

Information visibility within the supply chain is the process of sharing critical data required to manage the flow of products, services, and information in real time between suppliers and customers. If information is available but cannot be accessed by the parties most able to react to a given situation, its value degrades exponentially. Increasing information

[4] Ira Lewis and Alexander Talalayevsky, "Logistics and Information Technology: A Coordination Perspective," Journal of Business Logistics 18, no. 1, (1997), 141–157.

[5] This section is based on a benchmarking report developed by the following associates of the Supply Chain Resource Consortium: Steven Edwards, Meenakshi Lakshman, and a number of undergraduate students at North Carolina State University.

visibility among supply chain participants can help all parties reach their overall goal of increased stockholder value through revenue growth, asset utilization and cost reduction. To improve responsiveness across supply chains, companies are exploring the use of collaborative models that share information across multiple tiers of participants in the supply chain: from their supplier's supplier to their customer's customer. These trading partners need to share forecasts, manage inventories, schedule labor, optimize deliveries, and in so doing reduce costs, improve productivity, and create greater value for the final customer in the chain. Software for Business Process Optimization (BPO) and Collaborative Planning, Forecasting and Replenishment (CPFR) are evolving to help companies collaboratively forecast and plan among partners, manage customer relations, and improve product life cycles and maintenance. Traditional supply chains are rapidly evolving into "dynamic trading networks"[6] comprised of groups of independent business units sharing planning and execution information to satisfy demand with an immediate, coordinated response.

Some of the considerations that must be planned for in implementing an information visibility system include the size of the supply base and customer base with which to share information, the criteria for implementation, the content of information shared and the technology used to share it. Clarifying these issues will help to ensure that all participants have access to the information required to effectively control the flow of materials, manage the level of inventory, fulfill service level agreements and meet quality standards as agreed upon in the relationship performance metrics.

Dell's Information Visibility System: The Benchmark

Perhaps no other company has been as successful in implementing information visibility as a competitive strategy than Dell Computer. Dell has fulfilled its commitments to customers through the company's direct model, in which it holds only hours of inventory yet promises customers' lead-times of five days. Component suppliers who wish to do business with Dell have to hold some level of inventory, since their cycle times are typically much longer than Dell's[7]. For example, if a supplier has a lead-time of 45 days and Dell is promising on-line customers a lead-time of 5 days from order placement to delivery, the supplier must have real-time information to meet Dell's strict demands. Dell has developed a business model that features a lean, build-to-order manufacturing operation. By utilizing the Web, Dell provides its supplier with forecasting information and receives information about the supplier's ability to meet the forecasts. Dell uses i2 Technologies products for demand-fulfillment operations and products from Agile Software for engineering-change-order and bill-of-materials management. Communication among engineering changes, component availability, capacity, and other data between Dell and its suppliers flows both ways, in addition to forecasting and inventory data. Dell is also able to review suppliers and place Web-based orders into their factories in hours. After outsourcing to third party contract manufacturers, Dell executives realized that many of these manufacturers did not have adequate visibility of customer orders. This was a major driver in the initiative to increase visibility of orders. Dell's build to order web-based customer model has become the benchmark for other industries, and organizations such as General Motors,

[6] Cole S.J., Woodring S.D., Chun H., and Gatoff J., 'Dynamic Trading Networks', *The Forrester Repor*t, January 1999.

[7] Lewis, Nicole. "Valuechain.Dell.Com Provides Pipeline to Info Exchange." Dell Portal Adds 'Value'. CMP Media Inc., 2001

Ford, General Electric, and others are seeking to create "build-to-order" models using the Web as the platform for taking customer orders.

Benefits of Information Visibility

Information regarding forecasts, changes in production schedule levels and on-going supply chain performance metrics needs to be conveyed by customers to suppliers on a regular basis. Information flows from suppliers to customer can include current order lead times, capacity levels, order status and inventory levels. The benefits of having parties receive this information are numerous. Receiving and conveying the correct information will ensure that the suppliers are aware of what needs to be produced while at the same time, the buying firm is sure that it is possible to receive ordered quantities on time, every time. The most important benefit of a visibility system is not that the system is able to correct a supply chain problem, but that it allows people to become aware of problems earlier, and thus take corrective actions more quickly than they would otherwise. The benefits of information visibility include reduced lead times, improved constraint management, better decision-making, lower costs, and increased profits. Although, problems such as shortages, changes in customer orders, engineering changes, obsolete inventory, and equipment failures can still occur with a visibility system in place, the effects of these problems are less than if the participants in the supply chain were not made aware of these problems until a later date. In other words, visibility systems may be able to turn a potential $500,000 problem into a $5,000 problem.

When implemented properly, a visibility solution results in the following additional benefits that promote improved supply chain performance:

- ***Breaks organizational barriers.*** Enables sharing of mission-critical information about business activities and interaction on a near real-time basis across the supply chain.
- ***Builds visibility into supply chain.*** Provides people a real-time snapshot of supply chain performance metrics.
- ***Managing by metrics.*** Aligns performance metrics with cross-organizational business processes and assigns ownership of processes and metrics to specific individuals.
- ***Reduces the decision cycle process.*** Allows an upstream or downstream participant to respond to market or customer demand in hours or days, not weeks and months.
- ***Encourages decision-making collaboration.*** Facilitates the ability to make decisions collaboratively on the Internet, bringing relevant internal and external stakeholders into the process.
- ***Reduces opportunity and problem resolution latency.*** Measures and monitors supply chain activities iteratively allowing people to quickly respond to events as they occur.

Conversely, the dangers of poor execution of supply chain processes include increased lead and cycle times, higher costs, and less informed decision-making. For an example, in the semiconductor industry, a lack of visibility across the supply chain, coupled with inaccurate supply/demand forecasting, is hurting the industry's ability to deliver products promptly, efficiently spend capital, and properly manage inventory.[8]

Analysis Methodology

The focus for this project was narrowed down to analyze only those processes that are directly related to the convertible top automobile fabric that is manufactured by a large textile manufacturer (A) and is handled further up in the supply chain by a company that coats

[8] Lewis, Nicole. "Valuechain.Dell.Com Provides Pipeline to Info Exchange." Dell Portal Adds 'Value'. CMP Media Inc., 2001

the fabric (B), one that completes the cut and sew operations (C) and the final OEM assembler (D). The product in question was a convertible top for a sport vehicle. Initially, a broad view of the supply chain map was developed using publicly available information on the industry. Additional information was collected by talking to various individuals who had prior knowledge of the processes specific to this industry. In order to fill the gaps in the initial supply chain map, a questionnaire was prepared and sent to each supply chain partner. The focus of the questionnaire was to gather information that could potentially be used to study the inventory levels, service and responsiveness in the supply chain. The information collected from the questionnaire was then used to fill the gaps and complete the supply chain. The data collected from supply chain members were then used to identify:

- Areas of low inventory turns in specific areas of the supply chain
- Potential areas of improvement across the supply chain members
- Information requirements to help alleviate the problems detected during analysis

Market Analysis

The automobile industry is currently one of the most important industries in the U.S. economy. One out of every seven jobs within the U.S. is related to the automobile industry, either directly or indirectly. Scale and efficiency are extremely important to all of the industries large manufacturing firms. This is necessary to keep costs down and enhance profit margins.

Structure of OEM's Value System

In the automobile industry, suppliers to OEM's do not have much power—the automobile manufacturers pass down the general specifications, and it is highly unlikely that any one textile supplier could cause the major auto manufacturers any problems due to the number of current suppliers and potential suppliers who desire to be in the Automotive Supply Chain.

The buyers, defined as the dealerships, do have some legal power as a group. To date, they have been able to stop the major manufacturers from forming a direct link to the end-consumer, but that may change soon. Again, however, no one dealer has the power to cause major problems for any of the manufacturers.

The automotive industry is very capital-intensive, requiring plants to be built, equipped with machinery, and staffed with people. In general, this makes the threat of new entrants relatively low, as any company wanting to get into this industry would have to expend large amounts of cash before seeing even the slightest return on investment. However, many textile manufacturers possess the capital equipment necessary to manufacture products for the automotive industry by realigning their products/markets. The potential for such activities increases as the textile industry lessens its historic dependence on the apparel industry as its largest buyer of textile fabrics. In addition, trade agreements such as NAFTA and CRAFTA create an opportunity for off-shore foreign suppliers to enter the Automotive Supply Chain as well.

Within the U.S., there really are no substitutes for cars and trucks. While a few cities have implemented very successful mass transit systems, for the most part U.S. cities are too spread out for these systems to be effective.

The global competition at all levels in this industry is very fierce, especially with the capacity to produce 80 million vehicles by 2002, and actual demand is expected to be only 60 million units. This will create greater and greater need to drive costs down and focus on specific areas of competition.

In the year 2000, the U.S. automobile industry again set an all-time record high in sales of automobiles and light trucks by reaching 17.4 million units. The previous record (from 1999) was 16.9 million units. This rise was attributed to the U.S. economy, higher personal income growth, and enhanced consumer confidence. However, the U.S. economy has recently begun to soften, which could reduce sales to between 16.5 and 17.0 million units in 2003.

TABLE I. AUTOMOTIVE INDUSTRY SALE COMPARIONS

Region	**I. Units sold 2000 through 2003**[9]
United States	- 2000 approximately 17.4 million units - 2001 between 16.0 and 16.5 million units - 2002 approximately 16.8 million units - 2003 approximately 16.6 million units
Europe	- approximately 17.7 million units, compared with 17.8 million units sold in 2000 (both figures based on 19 markets)
Brazil	- approximately 1.6 million units, compared with 1.5 sold in 2000
Australia	- approximately 780,000 units, compared with 788,000 units sold in 2000

The U.S. automobile manufacturers have continued to emphasize profitability over market share. Moreover, profit margins are under pressure as well. Thus any significant reduction in production volume will put company's profits under even more severe pressure.

Currently, the U.S. market for new passenger cars and light trucks is quickly approaching saturation. There's little indication that, on a long-term basis, annual growth will be over 1-2 percent. As a result, the major automakers are turning to developing countries for additional growth. These countries include China, Malaysia, Indonesia, and India. While all of these are rather large markets, the average incomes are low, although there are a number of extremely wealthy people in these countries. Nevertheless, U.S. penetration into these international markets will likely be lower due to competition from European and Asian automotive manufacturers. This could prevent sales penetration in the short run.

The single biggest expected change is the growth of the Internet in researching and purchasing material goods. Consumers are increasingly using information from the Internet to determine such things as features, specifications, styles, and designs of different makes and models. It is reported that 62% of new car buyers use the Internet as a resource during their buying decisions. In addition, consumers are increasingly demanding more and more flexibility and options in what they can purchase. The industry may soon be able to implement the process of Mass Customization, thereby circumventing the middleman and deal directly with the purchaser. This is an effort to reduce the huge amount of inventory that exists in the automotive supply chain (see Figure 1.).

[9] http://www.ford.com/2000annualreport/mda_8.html

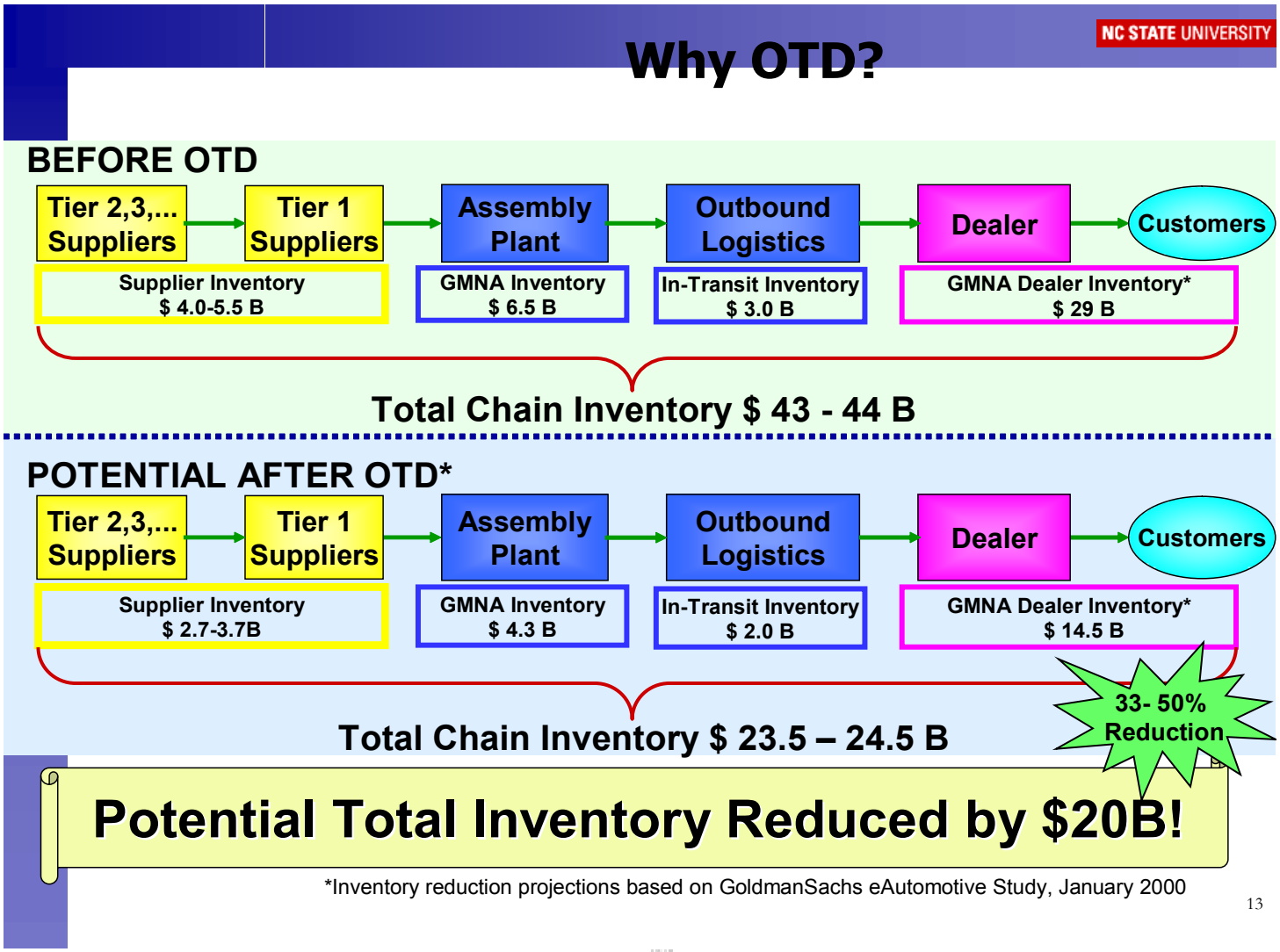

Figure 1. Impact of Mass Customization of Autos on Automotive Supply Chain.

Cut and Sew Operations

The Cut and Sew industry is considered fragmented with a great number of competitors providing this service. The level of computer integration and automation distinguishes the key competitors from the rest of the competition. Some competitors rely almost exclusively on manual labor while others have computer-controlled pattern cutting to allow for exacting specifications. It is expected that since this is a Tier 2 supplier to the automakers, Cut and Sew operations would fall into the latter (automated) strategic group. Cut and Sew operations provide service and sell into other markets as well. These would include the apparel and home

furnishings industries, which could be a larger portion of their businesses.

Just In Time Component Suppliers

The automotive components supplier business (cut and sew) is also fairly fragmented. This industry is also mature with some consolidation among competitors. These participants compete fiercely and directly with one another in many of the markets serviced by this industry. Different competitors compete directly on a cost, quality and flexibility basis or carve out niche markets such as convertible tops in which they are differentiated by their technology and "turnkey" systems. Rivalry among participants is high, but this is a niche market with few players. In fact, it is not unusual for a tier 2 or 3 company in this specialized convertible top market to have a market share of 60% or greater.

The automobile manufacturers possess significant power due to their small number in the OEM sector and relative size compared to the remaining tiers in the supply chain. The automobile makers are not likely to backward integrate into niche markets, as it would not fit their core business. On the other hand, companies within the various tiers are a credible threat for forward integration. For example, Collins and Aikman began as a window shade manufacturer in 1843 and expanded into the textile fabric business 1872. Over the years it became a major supplier of textile products to the transportation industry. By the mid 90's, over 60% of its business involved the automotive industry. At that time a strategic decision was made to become a major supplier to the 1st and 2nd tier suppliers in the Automotive Supply Chain. This was accomplished through mergers and acquisitions of companies in other supply chains serving the automotive industry.

Forward integration does, however, have limitations since companies may be less of a threat to the completed convertible top automotive component market due to the complexity of mechanical design for these parts. Substitutes for these products include vinyl tops and conventional steel hardtops. A car buyer interested in a convertible vehicle has likely decided that neither of these is a legitimate option. The threat of substitutes is low.

Competitive Advantage

Demand for Convertible Top products tends to be proportional to fluctuations in demand for automobiles/light trucks in general.[10] "Overall sales volume may now be settling at a higher plateau. From 1994 through 1998, the U.S. light vehicle markets volume stayed mostly within a range of 15.0 million to 15.5 million units. However, in 1999 it surged to 16.9 million units, reaching 17.4 million units in 2000. These results suggest a possible breakout from the old range into a permanently higher annual sales rate, even though cyclical variations are likely to remain. If this is the case, then normalized quantity may be higher than previously thought. Leading the increase has been rising sales of non-passenger car vehicles, such as light pickup trucks, SUVs, and minivans. While passenger car sales declined by 6.1% between 2002 and 2003 light truck sales rose 3.6%, bringing the market share for trucks to 54.3% in 2003, up from 48.5% in 1998.

The most important trends in the automotive industry are generally centered on two related developments: intensifying competition and globalization. Due to increased domestic competition, manufacturers are trying to enter foreign and niche markets by leveraging their brand and other competitive advantages. Innovative design and innovative features such as safety measures, sensors and global positioning

[10] Hoovers profile on the automotive industry

systems are crucial for successfully expanding the niche customer base. Automobile design is becoming more technology intensive. The use of electronics is growing not only under the hood but in the passenger compartment as well.

The suppliers of original vehicle parts and replacement parts (also called aftermarket parts) are being forced by automakers to provide parts that are of better quality and last longer than ever before. While good for the consumer and carmakers, this trend has weakened profitability for manufacturers and sellers.

Faced with retail pricing pressure (from both dealer showrooms and aftermarkets), the Big Three in recent years have demanded substantial cost reductions from their outside parts suppliers. Suppliers, in turn, have responded with aggressive programs to enhance productivity and improve efficiency, learning to function in an era of price freezes and reductions. As automakers pare their rosters of suppliers, they increasingly favor companies that can deliver modules (a combination of attached parts) and systems (a functional combination of modules), rather than individual parts. Their ever-increasing demands are leading to consolidation among automotive parts suppliers, for whom mergers and acquisitions are ways to cut costs and provide more modules and systems.

Results of Supply Chain Mapping

Current Practices/Linkages

After collecting data from an actual Automotive Supply Chain, it was organized into three key areas: Operations, Orders, and Logistics. The data in each of these areas were used to determine where each company stood with respect to the entire supply chain.

Operations

The first area is operations which contains information such as cycle time (in days), the forecast communicated to the upstream partner, batch size, and the number of days supply in inventory. As can be seen in the Table II, the current inventory in the system rises by a large margin at the partners before D. As well, the communicated forecast from C down is about three weeks, where D gives 20 weeks to C. Inconsistencies in batch size exist between D and C (downstream), and A and B (upstream). This could also be a cause for the high inventory in the system. Finally, the Cycle Time in days increases dramatically as you move up the chain, from three days at D to 40 days at A. This, combined with the lack of an accurate forecast could be contributing to a bullwhip effect throughout the chain.

TABLE II. MATERIAL MANAGEMENT IN AUTOMOTIVE SUPPLY CHAIN

	Cycle Time (days)	Forecast Communicated	Batch Size	Inventory (days)
D	2	20 weeks	Lot-for-Lot	1.3
C	3	3 weeks	Lot-for-Lot	44
B	14	20 weeks rolling, 3-4 week lock	4,000 yards	47
A	40		5,000 yards	90

Orders

Orders are comprised of days of lead-time, mode of receipt, and how often orders are sent to the next partner in the chain. The mode of transmission and type of information exchanged varies between the various supply chain partners, as shown in Table III. While EDI is used between the

majority of partners, Phone/Fax is used between A and B. This could potentially cause problems in terms of order entry and confirmation, and also forecast entry and confirmation. While not a primary cause, this, along with the frequency of information exchange, could be a minor factor in the excess inventory in the system that was shown above.

TABLE III. Automotive Supply Chain Ordering Patterns

	Lead Time (days)	Order Receipt Mode	Frequency
D	---	---	1 week
C	7	EDI	3 weeks
B	21	EDI	4 weeks
A	28	Phone/Fax	---

Logistics

The final area is logistics—how the material gets from supplier to customer. Key points in this transaction (shown in Table IV) are transit time (and batch size), how often an order requires premium freight, and how often shipments are sent.

TABLE IV. LOGISTICS OF MATERIAL FLOW IN SUPPLY CHAIN

	Transit Time (days)	Size	Premium Freight	Shipment Frequency
D	1	---	<1%	Daily
C	5 (internal) 5 (external)	55 tops	<1%	25 days
B	2	4,000 yards	<1%	Weekly
A	3 (internal)	5,000 yards	<1%	---

The transit time, while minor in most cases, really balloons at C, with five days internal and five days external shipping. This is largely due to their cut and sew operation located outside the U.S. This decoupling of processes can cause more inventory to be held in the system—indeed, it seems as if approximately six week's worth of inventory is being held at both B and C to account for the international transit (redundant inventory). As well, the transit batch sizes are very different—4,000 yards to B every week, 4,000 yards to C every 25 days, but only 55 tops (or approximately 110 yards) to D every day.

One key point to note in these data is the lack of premium freight. While at first glance, this appears to be a good thing, it may be the result of the excess inventory that is present throughout the system. It seems unusual, especially in a supply chain of this size, with the great geographic disparity, to have consistently less than 1% of all shipments be premium freight. While this is not the cause of a problem, it definitely seems to point to too much inventory in the system.

Ideal Management Practices

Across an ideal supply chain, operational parameters, information management and logistical issues would be balanced to optimize the entire chain's total value proposition. This would provide

equitable economic value added for each of the chain participants. Implementation would involve minimizing forecast variance, seamlessly transferring accurate forecast and order data on a real time basis and maintaining optimal inventory levels at strategic points along the chain.

Operations

The ideal management system across an entire supply chain integrates functions between parties at each of the interfaces between partners. These typically are information transfers (forecasts and orders), inventory management and logistics. In turn, optimal management of these allows for all parties to optimize purchasing, inbound logistics, inbound quality control, receiving and storage, inventory control, order processing, production planning and scheduling, warehousing, outbound transportation and customer service within their own organization. Each member of the chain may have the opportunity to trade inventory management for information management.

Information Flow

Ideal information flow provides accurate, reliable electronic data interchange with high frequency and minimal personal intervention. This is optimal because it provides real time forecast and planning data that provides extended visibility and stability to the suppliers planning and production efforts. Orders that are transmitted with reduced personal intervention are less likely to contain errors that can disrupt information and operational flows. Likewise, visibility into supplier inventory and in-process commitments can give the purchaser some insight into the flexibility of the supplier to meet a special order or need, should one arise.

Logistics

Negotiation, dialogue and agreement would occur to reduce logistical bottlenecks that may inhibit material flow between parties. Strategic placement of inventory and optimization of freight operations, minimize the threat of stock outages or excessive inventory and obsolescence. The benefits of Just In Time delivery and manufacturing (low to no inventory carrying costs) might be obtained through cooperative efforts between supply chain partners. By analyzing the entire chain from a logistical standpoint, it may become evident that there has not been any optimization of the strategic placement and flow of material between members of the supply chain and significant savings may be available through a cooperative effort.

An entire supply chain overview provides an opportunity to optimize material and information visibility, availability and reliability within and between each supply chain member. Through ideal flow of information, cooperation regarding inventory placement and volumes, and optimization of logistical issues, each member of the supply chain would benefit. Each participant would have the best information available to establish optimal batch sizes to serve customer needs and plant operations to optimize use of assets and potentially improve cash flow. The entire flow of the supply chain is shown in Figures 2-5.

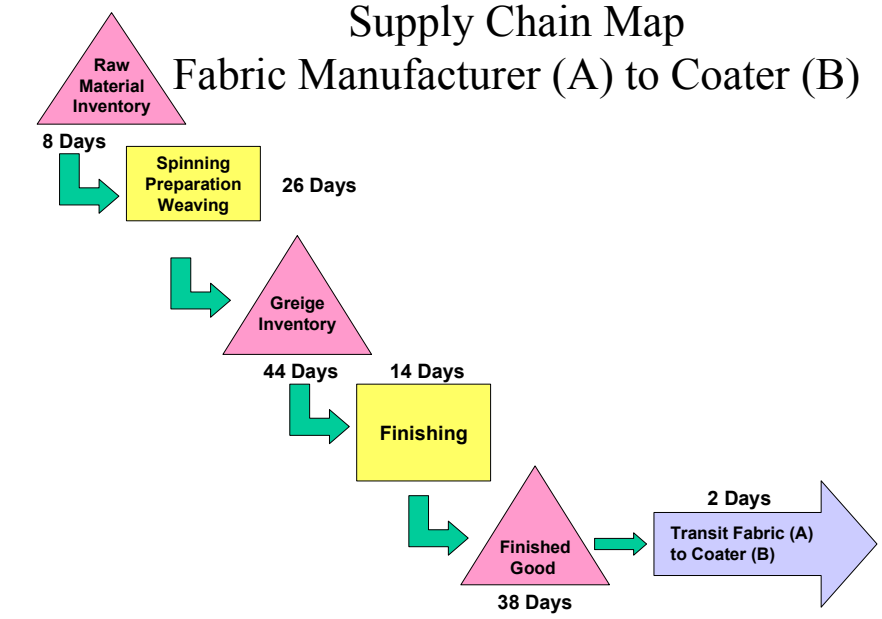

Figure 2. Supply Chain Map, Fabric Manufacturer to Coater

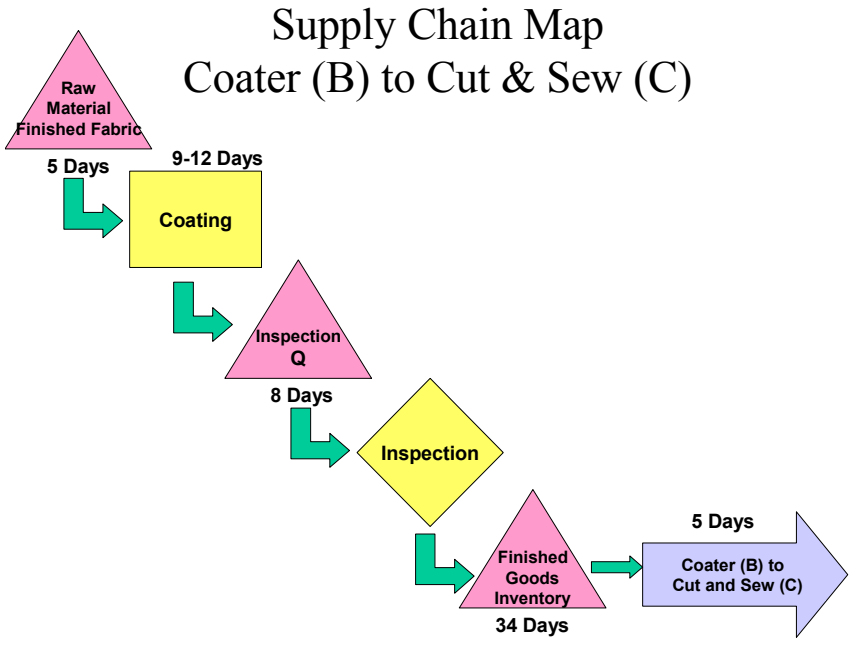

Figure 3. Supply Supply Chain Map Coater to Cut & Sew

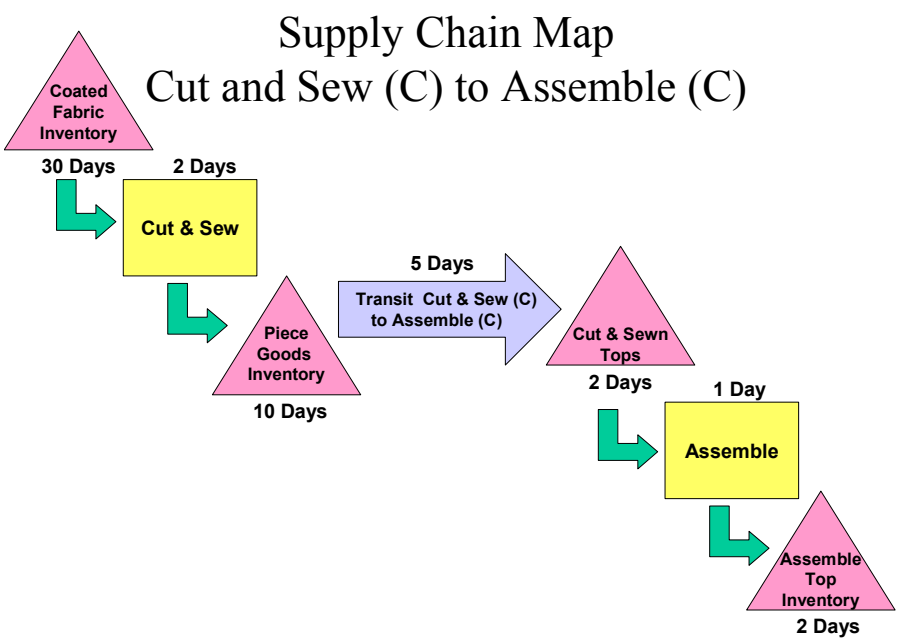

Figure 4. Supply Chain Map Cut & Sew to Assemble

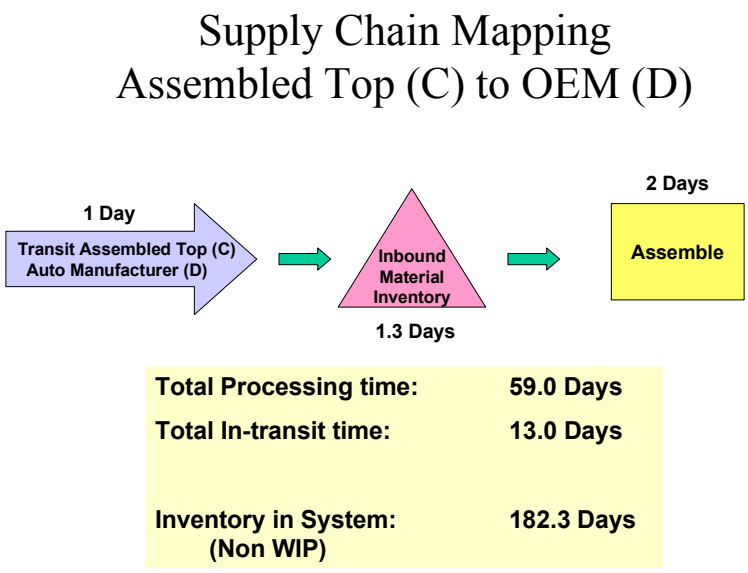

Figure 5. Supply Chain Map Assembly to Installation

Some of the potential reasons for this inventory based on analysis of the supply chain are shown in Figures 6.

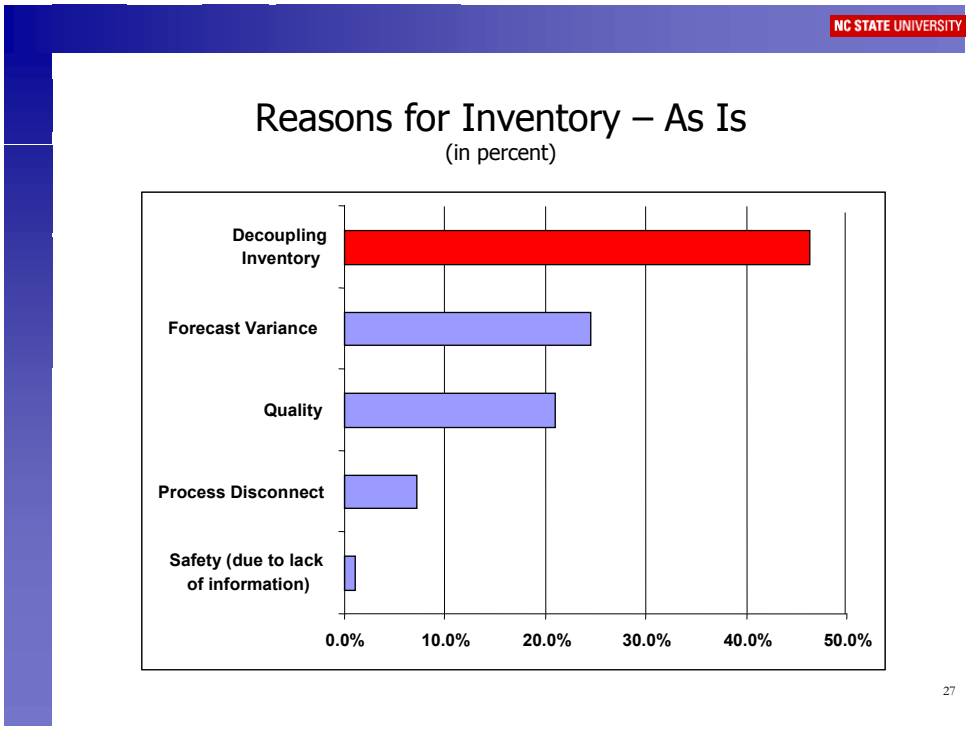

Figure 6. Reasons for Inventory in the Automobile Supply Chain Studied

Further, the amount of inventory in the chain is illustrated in Figure 7. The classic pattern of the bull-whip effect is evident, as the final company in the supply chain (the textile manufacturer) is left with the greatest level of inventory to hold, due to poor information visibility.

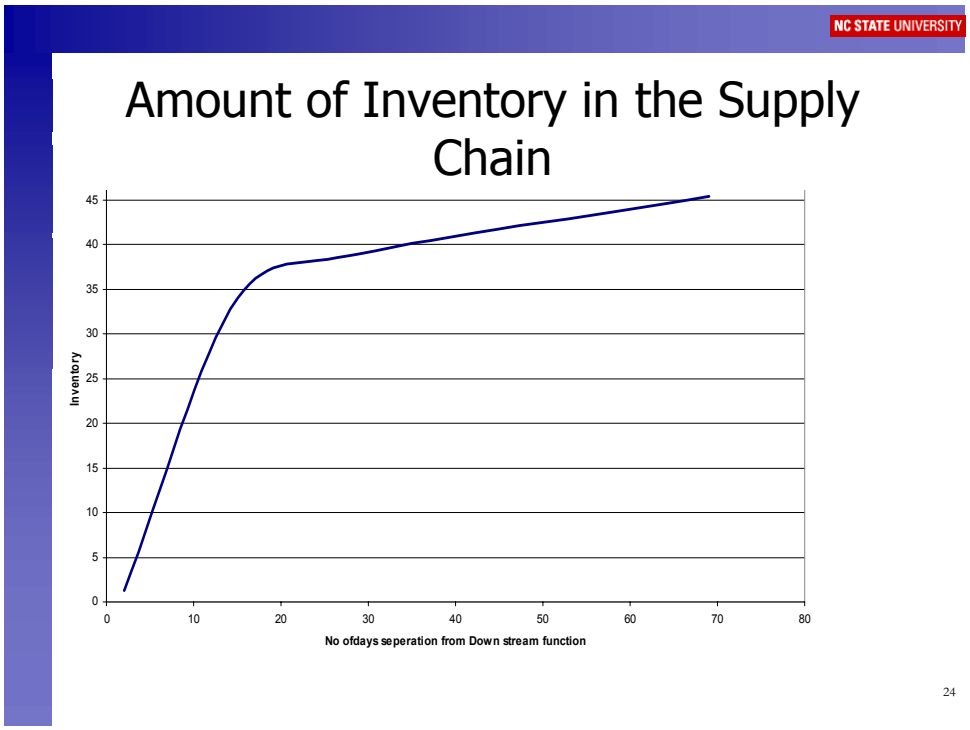

Figure 7. Bull Whip Effect in Automotive Supply Chain

Tactical Recommendations

When looking at any supply chain situation, one of the first areas for improvement is optimization of inventory levels. The proposed optimized supply chain in Figure 8 addresses these needs directly. The first recommendation is based on the removal of redundant and excessive inventory. As mentioned previously , the Finished Goods inventory held by B and the Materials inventory held by C are redundant. The two inventories occupy the same inventory point on the supply chain, separated by transportation time. It is our recommendation is that B should eliminate its Finished Goods inventory. By placing its cut and sew plant off shore, C increased the uncertainty and transit times in the entire supply chain. Therefore, it should be the one to incur the inventory holding costs. This inventory at B could be "replaced" with information, which could be provided by increased visibility of the forecast and improved information flows.

The second recommendation is that the forecast visibility should be improved across the entire supply chain. D generates a 20-week forecast that is shared with C. However, C only shares a three-week forecast to B and ultimately A. If B and A were afforded the original information, a more effective manufacturing process and inventory management system would be possible. Likewise, providing access to the one-week sequence schedule of D would decrease uncertainty at B. Increasing the forecast visibility would allow for more effective and efficient planning schedules that would reflect demand more closely, thus allowing overall reduction of inventory. All of the recommendations mentioned to this point would also improve the area of flexibility for the supply chain partners by allowing for less carrying costs, thus freeing capital. Ultimately, the area of customer service would be improved as well, due to each member of the chain (under D) being "leaner" and more flexible. This would allow for responsiveness to improve among the members.

Another area for improvement identified is information flow. Currently, A receives orders via fax from B. However, an EDI or web-based ordering system would prove much more effective. First, the orders would be much easier to track. The possibility of human error is greatly decreased as the ordering system becomes more and more automated. Next, an order placed by fax has a chance of being misplaced, especially if the fax machine utilized serves other different purposes. An electronic means of ordering would provide a "dedicated" place for orders to be received. Finally, there is the issue of speed. With internet connectivity growing faster each day, the time saved by ordering electronically instead of filling out and faxing a form could turn into a significant savings opportunity. Improved information flows would not only allow for faster reaction to orders, improving customer service and responsiveness, but it would also provide real time information about demand.

Insourcing/Outsourcing Consideration in the Value System

A final area requiring further study involves significantly reducing the size of the supply chain as a whole. It would improve the entire supply chain if the international plant of C's cut and sew operation could be eliminated. A thorough cost/benefit analysis would need to be performed. However, the time in transit alone serves as justification for exploring alternatives. If C is willing, the operation should be relocated to the US, preferably in a location closer to B or C's Assembly plant. On the other hand, another alternative would be for B to forward integrate into this area, shipping the material directly to C's assembly operation. Further, a second option would be to outsource the cut and sew function to another company, preferably more conveniently located to the entire supply chain.

CONCLUSIONS

There are several essential requirements to going forward and realizing the recommended improvements in the automotive supply chain. The first step is an improved mechanism for sharing and receiving information. Currently, information is shared on a periodic basis ranging from weekly to monthly. This inconsistent information sharing amplifies the bullwhip effect in the supply chain. The validity of the information is in question as well due to intermediate suppliers hedging demand to insure sufficient materials are on-hand. A solution to this inefficient visibility system is for OEM assemblers to provide visibility in depth throughout the supply chain. By penetrating deep into the supply base, variability and uncertainty can be reduced significantly by eliminating demand hedging activities and delays in information transfer between the different tiers of suppliers. This system also allows assemblers to control the type of information that is shared and reduces the likelihood of data entry errors.

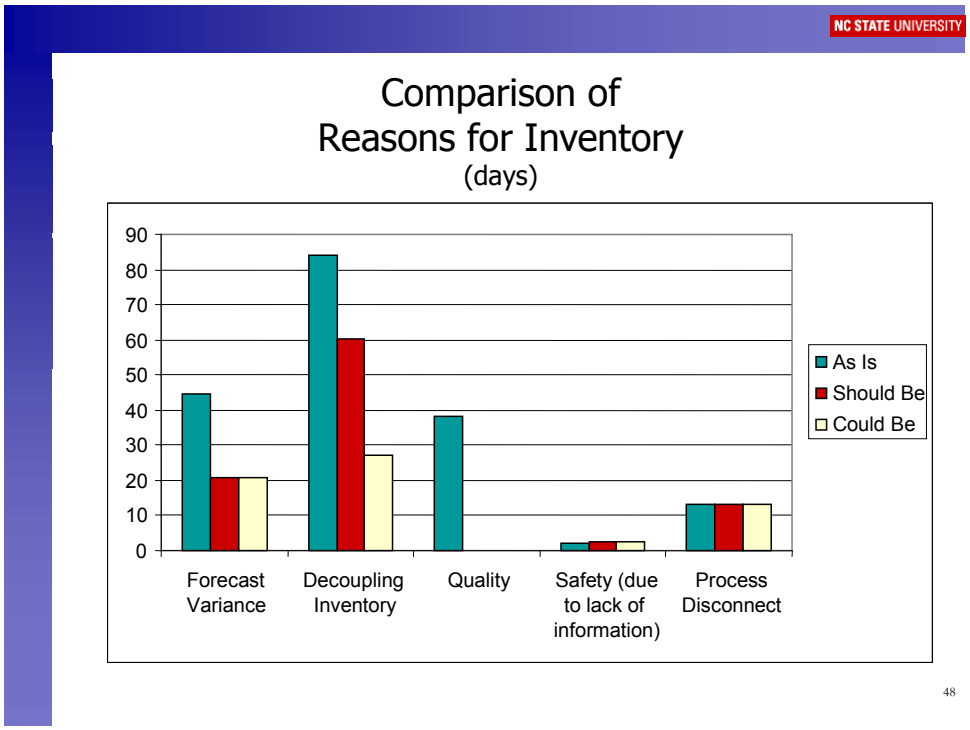

Figure 8. Potential Inventory Reductions by Type.

Supply chain evaluation and control should be incorporated into the system to measure current performance and the effect of supply chain initiatives. A series of shared metrics that accurately reflect the drivers of value and cost in the system is required to accurately gauge performance. Metrics should be non-financial in nature to allow for measures that accurately reflect supply chain performance while maintaining firm privacy. A series of recommended supply chain performance metrics that ultimately lead to increased value and lower total cost of ownership in this supply chain are listed in Figure 9.

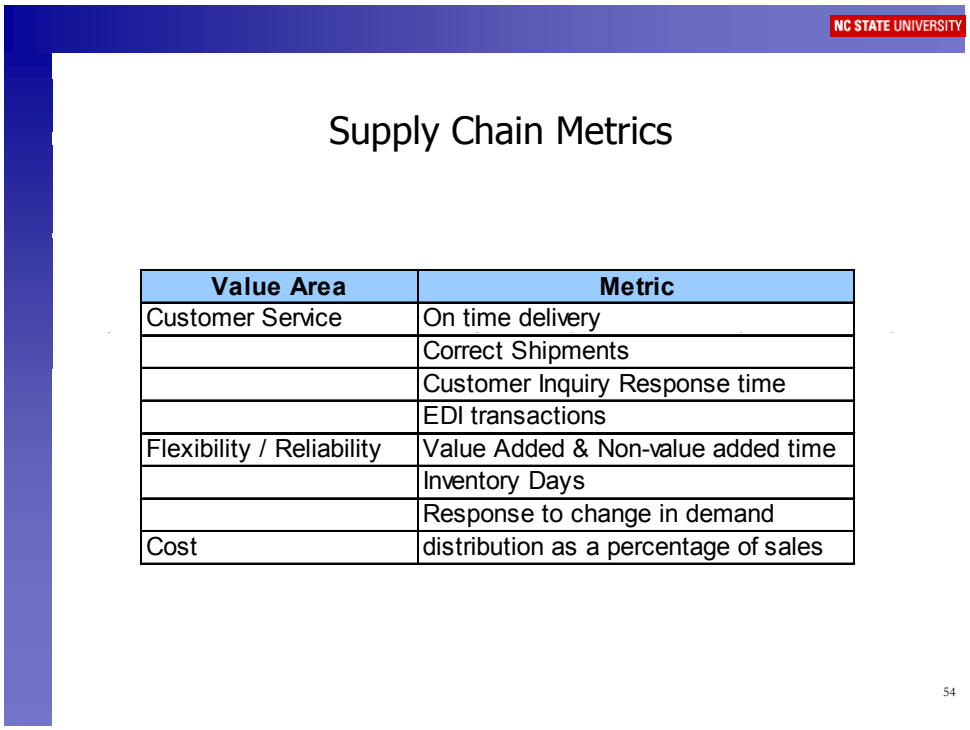

Figure 9. Recommended Supply Chain Metrics.