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MEP Supply Chain
OPTIMIZATION

CMTC's MEP Initiative for
Supply Chain Optimization

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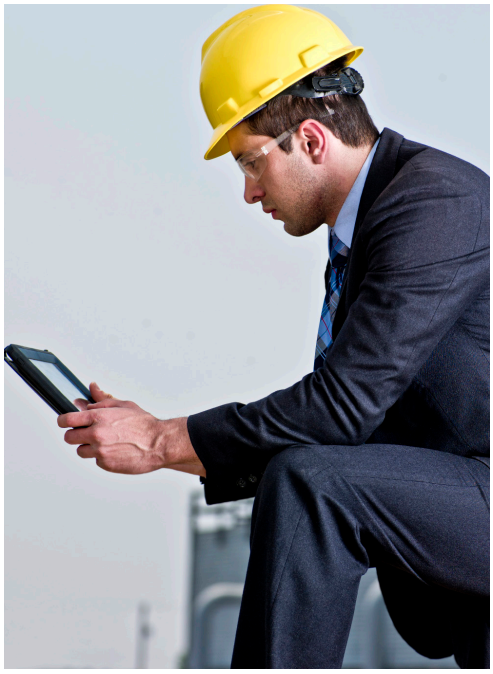
Have you looked at all aspects of cost, performance, quality, and value of your Supply Chain?

- Is the supply chain performing to the specifications of your Supply Chain Strategy?
- Do you even have a Supply Chain Strategy, and if so, is it in alignment with your corporate strategy?
- Are your suppliers aware of the supply chain strategy and do they know what their part is in helping to achieve it?

When was the last time you really looked at how effectively your supply chain is performing?



This ebook will provide an overview of the Supply Chain Optimization process and preview some of the concepts and tools that are part of the Manufacturing Extension Partnership (MEP) Supply Chain Optimization Initiative.

The Optimization Initiative is based on establishing a comprehensive view of the supply chain and improving the visibility and responsiveness through all tiers supporting the supply chain. It is designed to be scalable, to leverage and coordinate throughput improvements at any level of the supply chain, whether it is supporting a small to medium-sized contract manufacturer or a large multi-national OEM, the concepts and tools are applicable.

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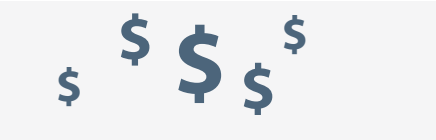
A high performing supply chain requires management attention to 5 critical areas:

Alignment

Alignment is perhaps the most critical element of an optimal supply chain. The supply chain strategy needs to actively align and support the long-term corporate goals of future growth, innovation, and sustainability. Alignment is pursued along three vectors: between supply and demand, between supply chain and company/brand strategies, and between the supply chain and partners.



Value

The supply chain strategy should identify suppliers who will assist in achieving your future goals through collaboration and in providing a means of growing your mutual businesses through the sharing of ideas, capabilities, and capacity.

Risk Management

A well thought out Risk Management Plan is necessary to prevent supply chain interruptions and unexpected events that would render your products uncompetitive, unavailable, or unattractive to the marketplace.

Visibility

The performance of the entire supply chain must be examined in order to identify current and potential future constraints. If you only look at suppliers who represent current bottlenecks, you will fail to recognize potential future constraints. Visibility is essential to enable all partners in the supply chain to overcome demand volatility.

Metrics

To achieve your goal of having a high performing supply chain, you need performance measures, or metrics, to show how well you are providing for your customers and how you are handling your business operations (speed, inventory, and financial metrics).

How to Develop an Efficient Value Chain or System

The Value Chain concept was developed and popularized in 1985 by Michael Porter, in "Competitive Advantage." Porter defined value as the amount buyers are willing to pay for what a firm provides, and he conceived the "value chain" as the combination of nine generic value added activities operating within a firm – **activities that work together to provide value to customers.**

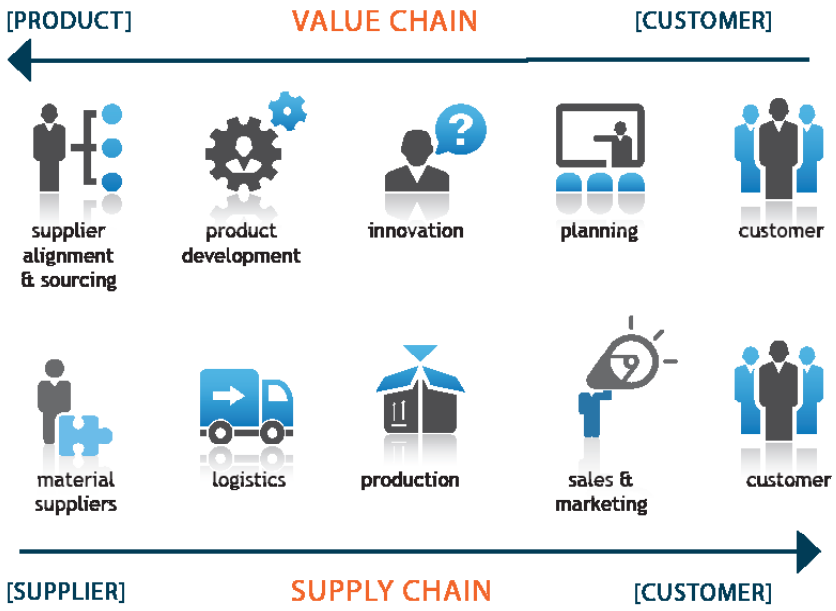


Figure 1: Value Chain and Supply Chain: A different perspective

The value chain and the supply chain are so closely related that it is essentially looking at the same flow from two different perspectives. The supply chain describes the flow of resources from the supplier to the customer. The value chain is the flow of value (as perceived by the customer) from the customer to the buyer. If the customer perceives no value in what the supply chain provides, there will be no demand. If the supply chain cannot deliver resources that the customer values (at the price the customer is willing to pay) there will be no flow.

Andrew Feller makes this distinction:

> "Supply chains focus upstream on integrating supplier and producer processes, improving efficiency and reducing waste, while value chains focus downstream, on creating value in the eyes of the customer."

- Value Chains Versus Supply Chains by Andrew Feller, Dr. Dan Shunk, & Dr. Tom Callarman - Business Process Trends - March, 2006

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The Optimized High-Performing Supply Chain

Our optimization activities need to employ System Thinking. We need to focus on improving the performance of the supply chain, but also focus on the supply chain's business objective to support the organization's business strategy.

The optimized solution is based on the prediction of the future constraint(s), the exploitation and subordination of both the current and future constraints, and the ability to successfully implement the control measures to validate the planning assumptions.

To perform best, now and in the future, we need to know the internal limitations of the system. Tactics should concentrate on the actual exploitation of the existing constraint(s), and the synchronized plan for key non-constraints (subordination).

We also need to provide some excess capacity at the constraint, to preserve our flexibility to respond to changing market requirements.

Getting It All to Work Together

The Manufacturing Extension Partnership (MEP) Supply Chain Optimization Initiative employs an engagement methodology that begins with the top tier, a supply chain maturity assessment, and a Strategy Development session.

Supply Chain Business Objectives

- ☑ Seek to develop partnerships and aliances with members of the supply chain strategically, with the goal of delivering goods and services as quickly and efficiently as possible.
- ☑ Use forecasts to plan and pull to execute. A system that reacts to pull signals will have less variation than a comparable system that adopts a push mode of operations.
- ☑ Reduce variation in the system. Reduced variation allows the supply chain to operate with higher throughput, lower investment, and lower operating expense.

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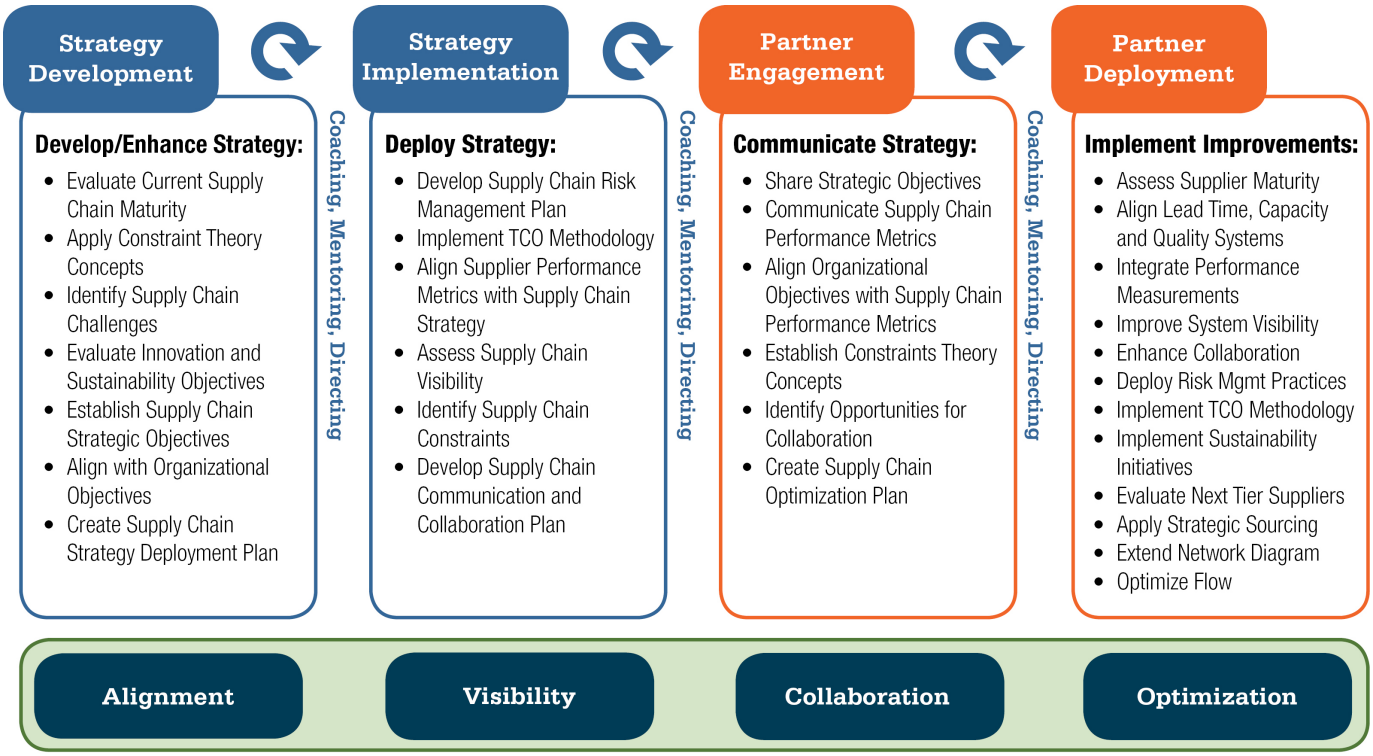
How to Create a Roadmap to Supply Chain Optimization



Top Tier Strategy Development and Development of Tactics for Deployment

During the Strategy Development session, the supply chain strategy and the plan for implementing the strategy and deploying it throughout the supply chain are developed. The supply chain is mapped and a critical chain analysis of the supply chain is done to identify those supply chain partners who will be engaged and in what sequence.

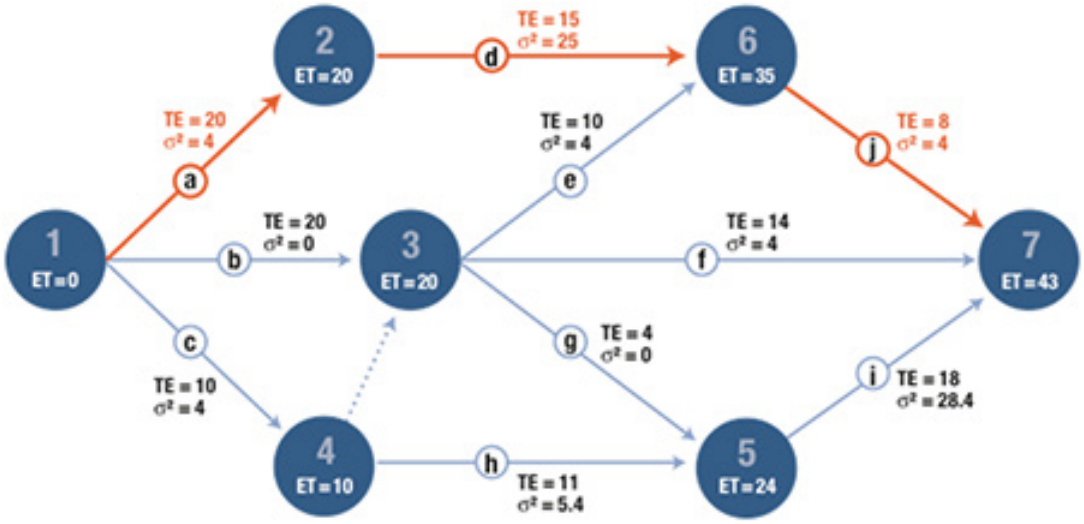


Figure 2: Determining the Critical Chain

The supply chain strategy is discussed in meetings with suppliers who are on the supply chain critical path. The actions needed to develop the throughput and capacity to meet current and future customer demand is planned.

Following the Roadmap to Supply Chain Optimization

Strategy Development

Develop/Enhance Strategy:

- Evaluate Current Supply Chain Maturity
- Apply Constraint Theory Concepts
- Identify Supply Chain Challenges
- Evaluate Innovation and Sustainability Objectives
- Establish Supply Chain Strategic Objectives
- Align with Organizational Objectives
- Create Supply Chain Strategy Deployment Plan

Coaching, Mentoring, Directing

Alignment

Stage One: Alignment

Alignment is perhaps the most critical element of an optimal supply chain. The supply chain strategy needs to actively align and support the long term corporate goals of future growth, innovation and sustainability. Alignment is pursued along three vectors: between supply chain and demand, between supply chain and company/brand strategies and between supply chain and partners.

Strategy Implementation

Deploy Strategy:

- Develop Supply Chain Risk Management Plan
- Implement TCO Methodology
- Align Supplier Performance Metrics with Supply Chain Strategy
- Assess Supply Chain Visibility
- Identify Supply Chain Constraints
- Develop Supply Chain Communication and Collaboration Plan

Visibility

Coaching, Mentoring, Directing

Stage Two: Visibility

A critical path analysis is performed to identify the supply chain constraints and the suppliers who are on the critical path. **(see Figure 2)**

A Supply Chain Risk Management Plan is developed in a hands-on one-day workshop to identify risks that could cause interruptions in the supply chain. A case study exercise is used to teach the process for identifying, analyzing, mitigating, monitoring and reporting supply chain risks. (See pages 11 & 12).

A one-day Total Cost of Ownership workshop is conducted to introduce strategic sourcing with the use of the Total Cost of Ownership. A case study exercise is used to teach the use of the Total Cost of Ownership Calculator for determining total cost and for testing multiple scenarios for strategic sourcing. (See pages 14 &15).

At this point, the strategy has been developed and is understood, we know what the short term and long term goals are. We understand the challenges that need to be overcome and we have a game plan to get there. We have examined our supply chain and understand where the risks are, where the bottlenecks present and future are located, and who the critical suppliers are.

We are now ready to communicate our strategy and game plans to our supply chain and begin the deployment phase of our optimization process.

Strategy Development Workshop

- Communicate Top Tier/Host supply chain strategy
- Supply Chain Fundamentals
- A brief introduction to Constraint Theory
- A three round supply chain simulation to emphasize the effects of variation and dependency
- Assessment of the Supply Chain Partner's Supply Chain Maturity
- Understand the Supply Chain Partner's role in the overall value chain and the impact/ interaction that they have on other members of the supply chain
- Develop strategies and executive tactics to address performance of Supply Chain Partners.

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How to Deploy Your Supply Chain Strategy and Communicate to Partners

Stage Three: Collaboration

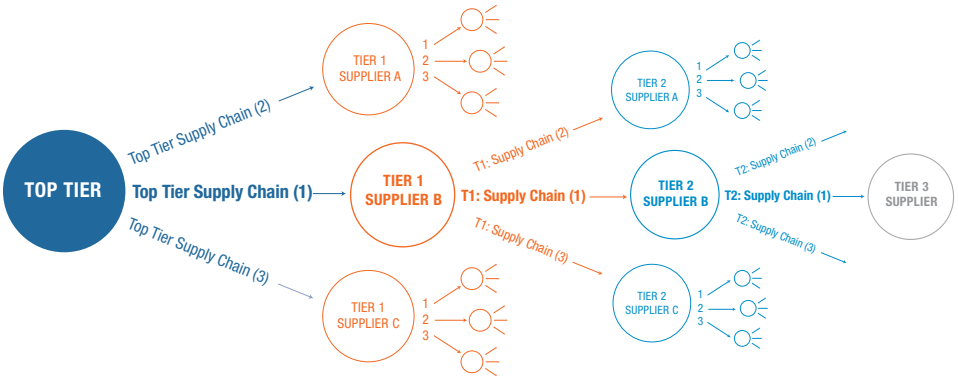
Once the strategy has been defined and the metrics developed, it's time to meet with your critical suppliers to communicate your strategy and work with them to develop their own supply chain assessment and improvement strategy.

Suppliers who are on the supply chain critical path are invited to a one-day meeting where your supply chain strategy is discussed, and current, midterm and long-term objectives are explained. The actions needed to develop the throughput and capacity to meet current and future demand is discussed. Suppliers need to be capable of responding to the variation in demand that is ever present in the supply chain.

An on-site evaluation is done to determine the supplier's current state and to assist them in the development of a long-term improvement plan. It is critical to include operational metrics for the periodic reporting of performance to plan. These metrics are used by the top-tier organization to make certain that the critical suppliers stay on track. If performance doesn't meet agreed to expectations, a correction plan is developed by the supplier to get back on track.

The top-tier organization compiles the periodic supplier reports into an easily read dashboard to assess suppliers who should be rewarded for progress and those who should be provided additional assistance. Suppliers can use internal resources or consulting assistance to achieve reductions in lead-time and improved throughput.

A collaborative approach needs to be used to encourage suppliers to make the improvements that help them to become a more valuable resource. Efforts should also be made to encourage innovation by the suppliers that can lead to additional value to your organization and to a more profitable business for the supplier.



The Twin Killers of an Efficient Supply Chain

The efficient flow of material through Supply Chains is subject to slow downs and interruption by what are known as the “Twin Killers” of flow – **Dependence and Variation**.

Understanding what these dependencies are and where/when they occur is important in optimizing supply chain costs and TCO. Not recognizing them makes an organization vulnerable to unpleasant surprises, which can drive up costs.

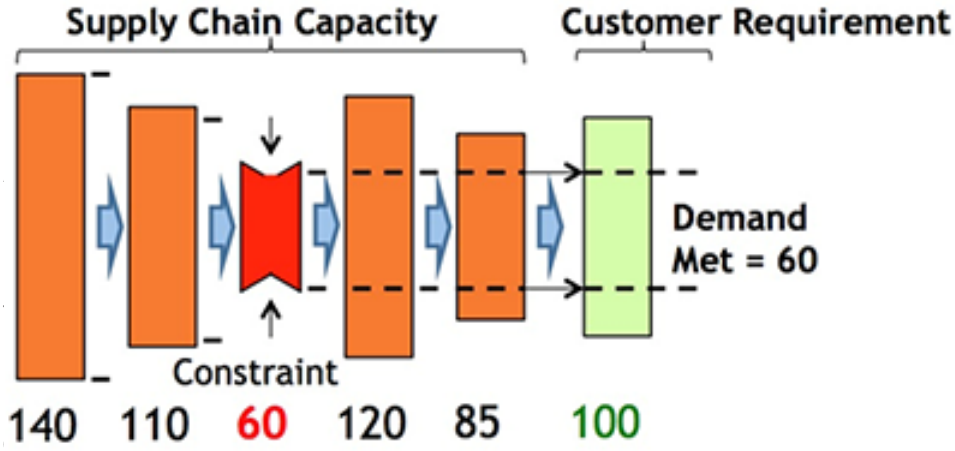
A Supply Chain or Value System map (see Fgure 1) can help identify these dependencies. We need to look at a supply chain as a system.

Each system is limited by a constraint, which prevents it from achieving a higher performance relative to its goal. In order to manage the performance of the system, the constraint must be identified and treated carefully.

Bottleneck vs. Constraint

A bottleneck limits locally the flow (e.g. to small waiting room, fluctuations): 1hour lost might be 1hour (or less) lost for the whole.

The constraint is a bottleneck that limits the whole chain: 1hour lost is definitely 1hour lost for the whole:



The “Twins Killers” - Dependence and Variation

Dependence is defined as:

- Existence of unavoidably dependent events
- Interactions between resources and products (capacity & supply with demand)
- Bottlenecks and a Constraint

Variation is defined as:

- Statistical variation
- Random events
- Batch processing
- Planning assumptions
- The bullwhip effect

Supply chain optimization depends on having a supply chain strategy that clearly defines the projected demand over time and then improving the identified critical path in the supply chain so that all suppliers are capable of meeting that demand (removing the constraints) and that there is sufficient capacity within the critical path to adjust to fluctuations in demand (variation). This needs to be accomplished along the entire critical path or the constraint will simply move from one node in the chain to another.

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What is Your Risk Management Strategy?

Risk is defined as an undesirable situation or circumstance that has both a likelihood of occurring and a potentially negative consequence. Over the last ten years we have seen volcanic eruptions in Europe, flooding in Thailand, earthquakes and tsunamis in Japan, hurricanes on the east coast of the USA and a typhoon in the Philippines. Each of these dramatic events had major negative consequences, and also resulted in serious supply chain interruptions.

Unless businesses whose supply chains were in these areas were prepared with a Risk Management Strategy, they undoubtedly suffered major interruptions in their businesses.

What safeguards exist in your operations to manage risk? Have you identified the risks that could impact your business? Some of the common risks that need to be considered are:

Supplier

- Relationship Risks – Loss of critical or strategic suppliers or customers
- Supplier Performance Risks – Poor quality or delivery from suppliers
- Supply chain disruption risks – Loss or delay of shipments
- Problems with manufacturing capacity
- Service failures due to longer supply chain lead times

Environmental

- Disaster Risks – Natural disasters incapacitating your business or that of your suppliers

Human Resource

- Human Resource Risks – Employee safety or performance problems, fatigue from excessive overtime work, warranty claims from quality escapes

Economic

- Regulatory Risks – Regulations, restrictions and taxes
- Operational/Planning Changes in customer/ consumer preferences

Geopolitical

- Political/Country Risks – Tariffs, import/export duties, political unrest, currency fluctuation

When supply chains are disrupted and businesses are impacted, they may, or may not be able to bounce back to where they were before the event. The survivability of the company depends solely on the company's resilience towards the disruption and ability to manage risk events.

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A Risk Management Program has four key elements that are tied together in a top-level Risk Management Plan

Risk Identification - You need to identify all of the undesirable situations or circumstances that have both a likelihood of occurring and a potentially negative consequence anywhere in any of our processes.

Risk Assessment - Analyze risks (determine likelihood, consequence, urgency, customer priorities)

Risk Action Management – Determine the appropriate risk management strategies and the early warning signals that will warn of an impending risk event.

a. Is the risk so minimal it is at an acceptable level

b. What can be done to eliminate risks?

c. What can be done to mitigate the risk?

d. Can the risk be transferred?

e. Do we need to accept the risk?

Risk Reporting and Monitoring – a formal Risk Management Plan is written and approved by management. All risk items are assigned to Risk Owners and a regular meeting for reporting monitoring for risk triggers and new identified risks is established. Ongoing monitoring is the most critical stage of risk management. In order to manage risks, they must be check on and new risks that become evident must go through the evaluation and mitigation activities.

Risk events will happen. Are you prepared to deal with them? If you have a current Risk Management Plan, you will be ahead of the game.

Developing a Risk Management Strategy

- ☑ Identify significant risks within the network
- ☑ Assess the probability of occurrence and loss severity
- ☑ Determine risk management strategies
- ☑ Build a risk reporting and monitoring plan

How Can You Determine Supply Chain Optimization vs. Supplier Development

When we experience disruptions in the supply chain whether it is caused by late deliveries, long lead times or poor quality, we look for the link in our supply chain that is causing the problem. Typically, we then try to work with that supplier to help them to improve whatever is creating the problem. Failing an adequate improvement, we look for a new supplier. This is "Supplier Development."

Supplier Development has been the traditional method used to improve supply chain performance. The suppliers causing the most problems in cost, delivery or quality are the recipients of our improvement efforts. The idea being that if I can just get this supplier to perform, all my supply chain problems will be solved.

More often than not, once the supplier we help is brought up to the desired performance level, we discover that the flow of product hangs up at yet another node in the supply channel. We then proceed through the supply chain in "Whack-A Mole" fashion "improving" each new supplier that emerges as "the problem."

We might also find that some suppliers just don't have the capacity to provide product at the level of demand required or they may not have the ability to respond quickly to changes in demand.

Critical Path Analysis (see Figure 2) helps us to determine the rate of demand required of each channel of our supply chain in order to meet our top tier strategy. The strategy we created earlier includes projected demand for near term, and long term. We can then look at the channel that composes the critical path and create an improvement plan that will bring the entire channel's ability to a level that can meet the demand.

The forecasted demand levels are shared with each of our supply chain partners and their capability to meet the capacity, quality and lead time requirements are assessed.

Supplier Development	Supply Chain Optimization
• Looks at poorly performing suppliers and works on improvements in isolation • This results in an improved single supplier, but another supplier is now seen as the constraint in the supply chain. • Improves the supply chain one supplier at a time (playing Whack-A-Mole) • Is one tool within Supply Chain Optimization	• Evaluates performance of critical path and level of demand required throughout the supply chain • Determines the suppliers composing the "Critical Path" and preventing performance of that channel at the required demand level • Improvement takes place at **all suppliers** on Critical Path to bring them up to the required level of demand • Draws from multiple tools to improve the whole supply chain

An improvement plan is developed with each partner to assist in bringing their performance in these areas to the levels required. When this has been achieved, we have optimized the supply chain.

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The Importance of Total Cost of Ownership (TCO)

Total Cost of Ownership ("TCO") is a concept that examines all of the costs related to the acquisition, transportation, and storage of products within the supply chain.

How is it different than the way we have always looked at supplier prices? Traditional costing methods such as Purchase Price Variance (PPV) typically miss between 20 to 40 percent of the actual costs of acquisition. These methods only take into account the price for which the supplier is willing to sell the item. It usually includes the supplier's manufacturing costs, overhead costs, and profit, but it may or may not include factors such as your costs for transportation and many other associated costs to bring the product to your location.

Let's take a look at a few of the additional costs that are included in TCO:

Shipping Costs

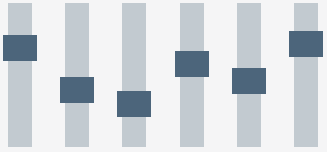
Shipping costs and complexity tend to increase with distance. When borders intervene and ocean (or air) transport becomes involved, the complexity goes up significantly because of multi-modal shipping with potential transfer, inspection, storage and documentation requirements associated with each mode involved. A company importing goods must comply with a range of U.S. government requirements as well as the export regulations of the country of origin. Upon arrival in the United States, arrangements must be made to file entry documents at the port of entry, pay the estimated import duties, and secure the release of the goods from U.S. Customs and Border Protection. Companies often employ agents or brokers to assist them with these tasks. Each step in this chain of events involves costs that are often missed when determining the true cost of a product.

Shipping Time

Travel time for a container vessel from Asia to the U.S. is between two and four weeks. Documentation, customs clearance, handling, and inland shipping can add 18 to 32 days to the total shipping time from most emerging market regions, and another 6 days once goods reach the United States. The impact that shipping time has on cost involves the need to carry sufficient buffer inventory to cover customer demands until replenishment inventory arrives.

Inventory

The cost of buffer inventory is often absent from the traditional determination of cost. Costs involve not only the dollar value of the inventory itself, but also the financing cost of the investment and carrying costs related to storing excess inventory.



Financial Data

Payment terms may be important to your choice of sources. Having to purchase a letter of credit or payment in advance requires financing and other costs prior to the availability of product for sale such as taxes, surety bond premiums, customs broker fees, and storage expenses.

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Quality Costs

Unforeseen or uncontrolled quality problems from a supplier may lead to:

- Lower product quality – increased inspection, unhappy customers
- Potentially costly product returns and shortages
- Possible legal liability
- Inability of supplier to meet certification, safety or other regulatory issues

Efforts to anticipate, control, mitigate or resolve the above quality issues will result in increased travel and oversight time and cost for this supplier.

Travel Costs for Supplier Oversight

Executives and other employees may need to travel to further develop or strengthen relationships; to oversee design, production, or shipping; or to resolve unforeseen issues like supply chain disruptions or production errors. Travel, labor and other related costs need to be included in the total cost of ownership.

Currency Fluctuation

When purchasing product from a foreign country with the payment due in currency of that country, the history of currency fluctuation must be taken into consideration. As an example, the price may be quoted for an annual contract, but during the year currency value versus the U.S. Dollar may have changed making the price higher in U.S. Dollars. In order to protect against currency fluctuation, you may choose to purchase a position on the foreign currency at the present price.

Intellectual Property

Protecting intellectual property (IP) rights is often a necessary step in both the United States and foreign markets. The United States has the world's strongest IP infrastructure, with the clearest and most cost-effective system for obtaining and enforcing IP rights. For small and medium enterprises (SMEs) in particular, protecting IP rights in the United States is easier than in most overseas jurisdictions. IP costs should be considered in the Risk Management Plan and the total cost of ownership.

Risk Management

A Risk Management Plan needs to take into consideration measures to prevent the interruption of the supply chain. These mitigation costs are part of the total cost of ownership. Long distance supply chains often introduce vulnerabilities and may necessitate securing larger inventories or multiple sources to safeguard against potential disruptions like transportation cost fluctuations, currency exchange rates, or logistic uncertainties, or other risks.

Managing an efficient, optimized supply chain requires us to understand the total cost of ownership and how it impacts the strategic sourcing process. It also helps to determine what improvements can be made with existing key suppliers to reduce our current total cost of ownership.

How Do I Assess Supply Chain Maturity?

Stage Four: Optimization

The supply chain strategy tells us what we need from our supply chain present, near term and long term in order to realize the objectives of our overall corporate strategy. Having performed a supply chain critical path analysis, we can determine at each of these levels where the real and potential constraints will be. The next step is to collaborate with the suppliers in that chain to communicate the strategy and how they can be a part of it. It is then necessary to evaluate each supplier's ability to meet the current and future demands by performing a supplier capability assessment of their operation. This assessment should be performed by an independent third party to avoid bias.

This is an on-site assessment of the suppliers operation to determine their ability to support the top tier's current and future demand as well as their ability to deal with variation in that demand.

Some of the key areas to be considered are:

- Lead Time from Initiation of an Order to Delivery
- Production Planning
- Purchasing
- On-Time Delivery
- Risk Management
- Quality
- Capacity
- Collaboration
- Response to Demand Variability
- Supply Chain Visibility
- Supply Chain Partnering Both Up and Down the Supply Chain

Each of these areas is addressed in a separate section of the assessment. For each area, the assessment provides illustrative diagnostic questions giving examples and suggesting potential metrics to help with the assessment process.

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Supply Chain Visibility

In most of the surveys we see about supply chain challenges, supply chain visibility consistently ranks near the top of the list. Most organizations don't have visibility of key supply and demand data from more than one tier up or down from their own position.

In the ideal world of a demand driven supply chain, flow of product to the end customer and from the furthest upstream supplier would be synchronized to provide a smooth and efficient flow of material that is also responsive to demand variation.

The goal of supply chain visibility is to reduce business and supply chain risk, while improving lead times and performance, and identifying shortage and quality problems along the supply chain.

So why is this ideal state so difficult to achieve? To understand the problem we need to first look at the real world as it exists today. To begin with, information in most organization exists in silos. The sales department has its projections and budget, production has its production schedules, buyers have supplier cost and delivery schedule data, etc. The focus of this fragmentation of data is designed to serve the purposes of the individual departments in the organization instead of that of the entire supply chain. In addition, each of the suppliers and customers has their own silos of information, not commonly shared with other supply chain partners.

So how do we get there from here?

Partner Deployment

Implement Improvements:

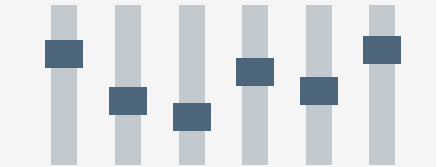
- Assess Supplier Maturity
- Align Lead Time, Capacity and Quality Systems
- Integrate Performance Measurements
- Improve System Visibility
- Enhance Collaboration
- Deploy Risk Mgmt Practices
- Implement TCO Methodology
- Implement Sustainability Initiatives
- Evaluate Next Tier Suppliers
- Apply Strategic Sourcing
- Extend Network Diagram
- Optimize Flow

Optimization

In a Gartner research paper the goal of supply chain visibility was described as follows:

> "The aim of end-to-end supply chain visibility (E2ESCV) is to provide controlled access and transparency to accurate, timely and complete events and data — transactions, content and relevant supply chain information — within and across organizations and services operating supply chains."

A concept that has gained a lot of discussion lately is that of the supply chain control tower. The control tower makes key data available to the partners in a supply chain that facilitates coordination of customer demand with supplier response. For a supply chain control tower to transform available data into usable information development is required in three areas:



Processes

Processes need to become more collaborative, with data sharing and planning being done across departments as well as between organizations. Coordination of sales projections and the supply chain can assist in helping suppliers to anticipate future demand. Organizations need to develop specific data requirements that can be shared between partners in the supply chain to make demand planning possible. Risk management needs to be implemented to mitigate the potential of supply chain interruptions.

Relationships

Information must be shared across processes not only within the organization within the functional silos such as planning, sourcing, production, and delivery, but also across business functions and outside the enterprise, providing a real end-to-end process view to all supply chain partners.

Collaboration between tiers is needed. This requires a level of trust between tiers that still needs to be developed. Information has to be shared across the supply chain in order to connect partners in the network and provide a real end-to-end process view.

Technology

A major challenge in the sharing of information between tiers is the problem of passing data between disparate information systems. How do you connect a company with an enterprise-wide ERP system with a supplier who manages their business on a spreadsheet?

Innovations such as cloud computing, and data collection and analysis software are now making supply chain control towers possible. Once a dataset is designed to give supply chain partners the information they need for sensing and shaping supply chain demand, the data can be communicated up and down the supply chain for analysis and planning.

The real time end-to-end data that the supply chain control tower provides enables companies to manage demand signals more accurately to reduce inventory levels, answer customers' requests faster and more accurately, and smooth the effects of demand variation.

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About CMTC and its California's Manufacturing Network

- CMTC is a private, mission-oriented non-profit corporation and part of the MEP National Network™
- The MEP Program is part of the U.S. Government's efforts to develop and deploy technology, management and technical expertise for improving the competitiveness of small and medium-sized manufacturers
- CMTC is the lead organization of the California's Manufacturing Network with service providers located throughout the state
- CMTC exclusively serves small and medium-sized manufacturers who are critical to California, as they represent 90% of job growth for high paying jobs, having a 3-5 job multiplier effect in the economy

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CMTC Services include:

- Growth and innovation strategies
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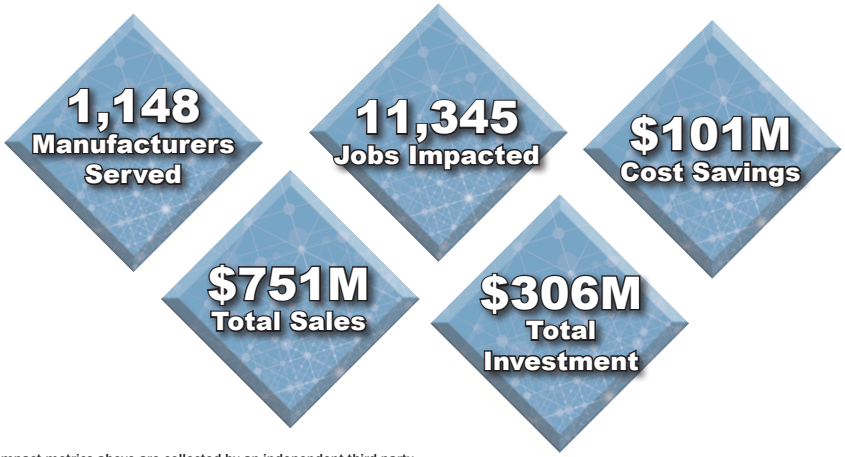
- Energy and environmental services
- Assistance in meeting quality certification improvements, such as those for AS9100 and ISO 9000
- Productivity improvements
- Health and safety compliance

For 2017, CMTC effectively and efficiently implemented a statewide manufacturing network that produced high client impact



All impact metrics above are collected by an independent third party.

MEP National Network™
The Go-To Experts for Advancing U.S. Manufacturing

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