Design for Supply Chain

A proactive process for introducing right products into right markets at the right cost

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Contents

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Introduction

There is no shortage of business or operational challenges that high tech product companies face in current market conditions. Short product lifecycles, competition, product variety, availability, global markets, fluctuating demand, steadily declining prices, increasing cost of components, component availability are just a few that make the short list. It comes as no surprise that so many high tech product companies face difficulty turning profits consistently. While product innovation may help in the short term it does not guarantee long term viability and growth. The only safeguard that high tech companies can build in such an environment is exceptional operational performance.

In a highly horizontal industry segment like high tech, operational performance is tightly connected to supply chain performance. Supply chain performance has a major impact on availability, lead time and total cost. Outside of the subjective factors that are related to market acceptance of the product, availability, lead time and total cost are the three major factors that define the profitability of a product line.

The current method that most high tech product companies choose for improving supply chain performance is to implement sophisticated advanced planning systems, operations management software and real time inventory management processes. These processes and systems have improved inventory management practices and clearly reduced the cost structure. But the focus of these processes and systems is operational and does not quite influence the design, manufacturing and supply chain decisions that set basic targets for supply chain performance of a product line.

On the other hand the product development phase of the product line offers a large opportunity to design superior supply chain performance. The product development phase offers wide latitude in terms of product design, components, manufacturing and supply chain strategies that can be used to achieve superior supply chain performance.

Little has been explored and done about the process of designing supply chain performance. This paper presents a business process and analysis approach for "Design for Supply Chain" that can be used during the product development phase to design superior supply chain performance into products.

Supply Chain Performance

The most widely used model for measuring supply chain performance is the Supply Chain Operation Reference (SCOR) model developed by Supply Chain Council (http://www.supply-chain.org). The SCOR model is unambiguous and can be used to measure efficiency and performance of the complete supply chain that includes the customer's customer and supplier's supplier.

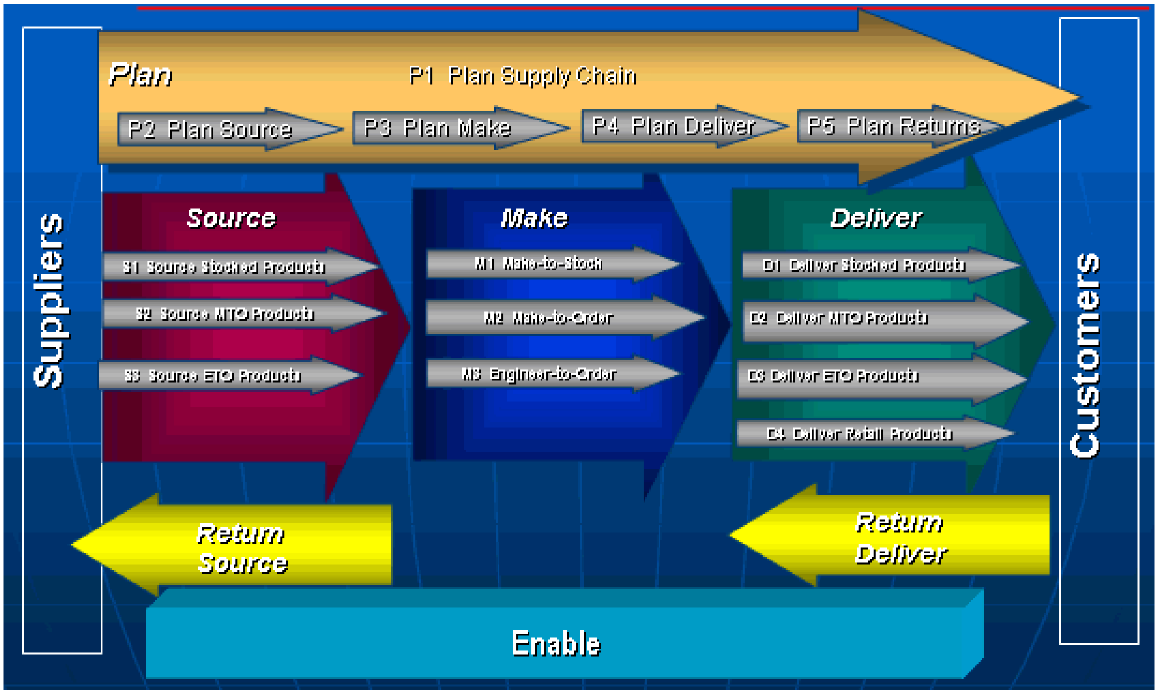


Figure 1: Supply chain operations reference (SCOR) model

There are many metrics that are appropriate for operation of a supply chain. But from a product line and "design for supply chain" process perspective the most appropriate ones are

- Availability – availability of product or components at the place and time where the customer or manufacturing process requires it
- Lead Time – Total lead time in the supply chain network
- Total Cost – Total cost of the supply chain and the product line

Clearly, the 3 metrics are interrelated in that it is possible to achieve 100% availability with zero lead times by stocking large number of end units and components at each node of the supply chain. However, the total cost would be exorbitant and the risk of inventory losses is high if market conditions change.

In addition to the above 3 metrics there are other product related considerations such as product configurability, production flexibility, postponement capability and robustness of the product to supply disruptions. These are more closely related to the product architecture and the marketing and sales approach taken (build/sell to order, sell from stock).

From the standpoint of product line business case, the total cost metric definition exceeds the cost metric captured by typical operational systems. The product line total cost metric includes the items as shown in the figure below

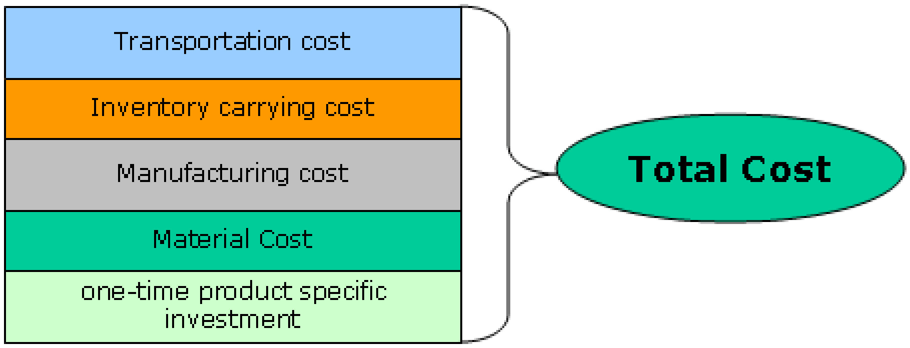


Figure 2: Total cost structure for the product line

Increasingly high tech manufacturers need to be concerned about service and end-of-life costs, but they won't influence supply chain performance. They are, however, important if a company uses total cost management (TCM) business process for product development.

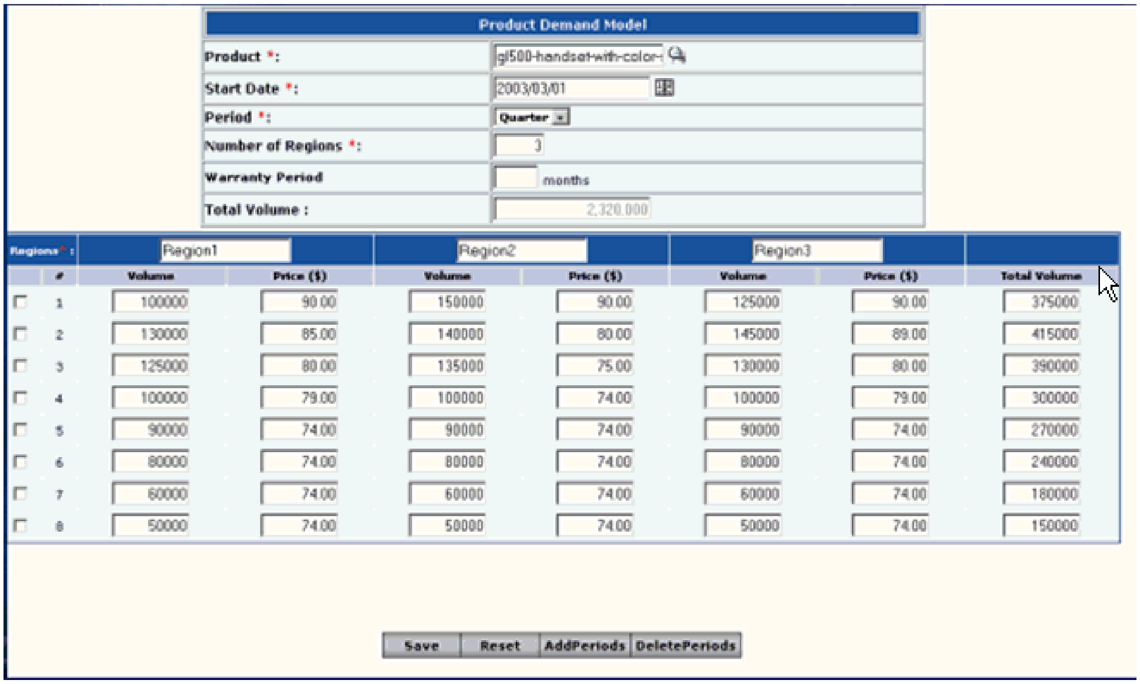
Designing Supply Chain Performance

The process and model for designing supply chain performance as part of product development is necessarily cross-functional and requires close involvement of marketing, engineering, finance, manufacturing and supply chain teams. The process and model requires inputs (estimates, real values and empirical values based on experience) from all of the above groups so that reasonable estimates of the supply chain performance can be obtained.

Is it typical to begin with a rough "Design for supply chain" model during the concept phase and continue to refine the model as more details emerge when manufacturing and supply chain strategies are finalized. In fact, manufacturing and supply chain strategies are selected based on their impact on supply chain performance.

Typical inputs from marketing include demand for the product in different market regions throughout the market window period. Engineering team designs the product to meet form, function, performance, and manufacturing and supply chain constraints. Manufacturing group begins with rough estimates of throughput and lead time for manufacturing processes and enhances the model with detailed *activity based models*. Supply chain team members contribute their strategies for distribution and component sourcing to meet the market demand and manufacturing demand respectively.

The various inputs provided for "Design for Supply Chain" process and model are shown in the following figures.



Product Demand Model

Product *: gl500-handset-with-color-

Start Date *: 2003/03/01

Period *: Quarter

Number of Regions *: 3

Warranty Period: months

Total Volume : 2,320,000

Regions * :		Region1		Region2		Region3		
	#	Volume	Price ($)	Volume	Price ($)	Volume	Price ($)	Total Volume
	1	100000	90.00	150000	90.00	125000	90.00	375000
	2	130000	85.00	140000	80.00	145000	89.00	415000
	3	125000	80.00	135000	75.00	130000	80.00	390000
	4	100000	79.00	100000	74.00	100000	79.00	300000
	5	90000	74.00	90000	74.00	90000	74.00	270000
	6	80000	74.00	80000	74.00	80000	74.00	240000
	7	60000	74.00	60000	74.00	60000	74.00	180000
	8	50000	74.00	50000	74.00	50000	74.00	150000

Save Reset AddPeriods DeletePeriods

Figure 3: Marketing view of the product line

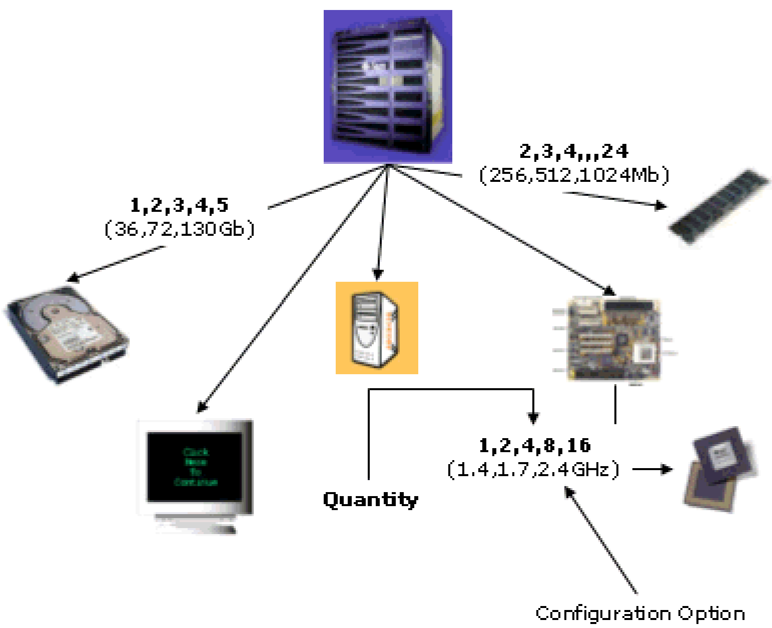
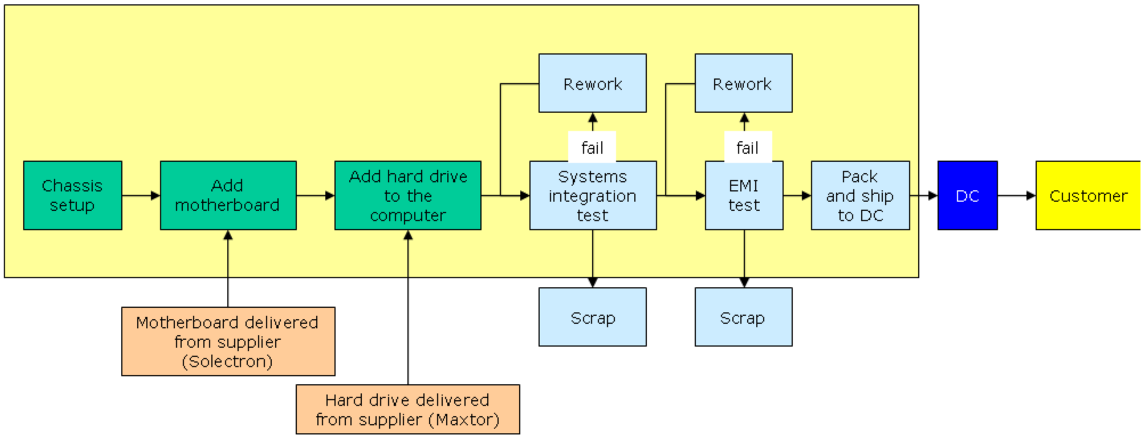
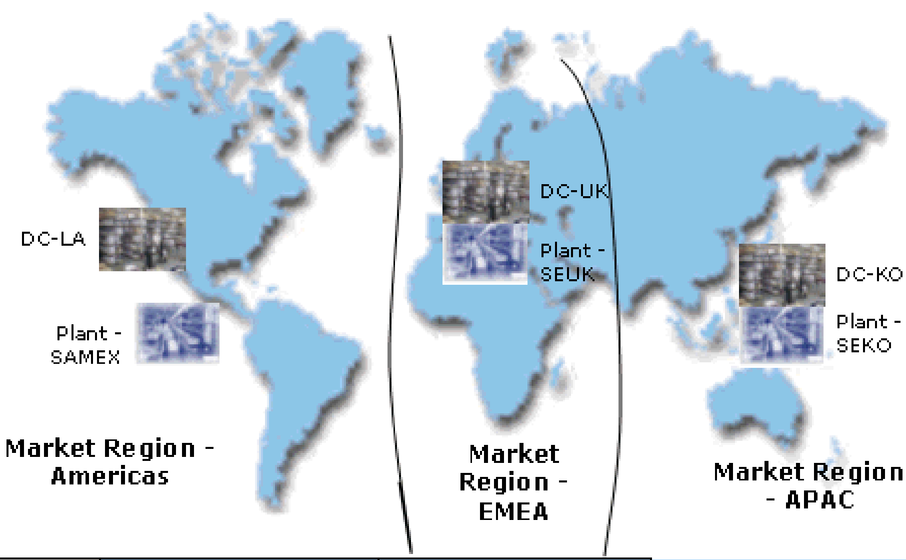


Figure 4: Engineering view of the product line



Process Activity	Lead time (mins)	Labor Cost	Yield	Variable Cost	Setup Time	Setup cost	Rework Cost	Scrap value lost	Capacity (units/hr)	Investment	Material(s) Used	Inventory	Inventory holding cost
Chassis setup	20	5	99.9	5			2	15	100	100000	Chassis	100	100
Queue													
Add motherboard													
Queue													
Add Hard drive													
Queue													
Systems integration test													

Figure 5: Manufacturing process view of the product line



Facility	Americas		EMEA		APAC	
	Transportation Cost ($)	Lead Time (days)	Transportation Cost ($)	Lead Time (days)	Transportation Cost ($)	Lead Time (days)
Plant-SEM	50	4	80	8	75	7
Plant-SEUK	80	8	40	3	100	10
Plant-SEKO	75	8	100	10	40	3
DC-LA	50	3	75	7	70	6
DC-UK	80	7	35	2	90	9
DC-KO	75	7	95	9	30	2

Figure 6: Supply chain view of the product line

Start Date:	2003/11/01		2003/12/01		2004/01/01		2004/02/01	
Sales Price *:	14,000.00		14,000.00		14,000.00		14,000.00	
Sales Quantity *:	10		10		10		10	
Warranty Period * (months):	36		36		36		36	
Sales Total:	140,000.00		140,000.00		140,000.00		140,000.00	
Direct Material Cost:	67,100.00	47.93 %	67,100.00	47.93 %	67,100.00	47.93 %	67,100.00	47.93 %
Manufacturing Process Cost:	16,050.00	11.46 %	16,050.00	11.46 %	16,050.00	11.46 %	16,050.00	11.46 %
Overhead Cost:	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %
Cost of goods manufactured:	83,150.00	59.39 %	83,150.00	59.39 %	83,150.00	59.39 %	83,150.00	59.39 %
Gross Margin:	56,850.00	40.61 %	56,850.00	40.61 %	56,850.00	40.61 %	56,850.00	40.61 %
Service and Warranty Cost:	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %
S G & A - Other:	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %
Investment:	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %	100,000,000.0	71,428.57 %
Adjusted Gross Margin:	56,850.00	40.61 %	56,850.00	40.61 %	56,850.00	40.61 %	-99,943,150.0	-71,387.96 %
Discount Rate:	%		%		%		%	

Figure 7: Financial view of the product line

Incorporation of "Design for Supply Chain" into the product development process

Most product organizations rely on Product Lifecycle Management (PLM) process and related applications to support product development in a methodical fashion. PLM process and applications offer a best practice business process for primarily managing product data, engineering changes and supply chain communication related to product development. In addition to engineering processes, there are several other simultaneous processes for manufacturing and supply chain development for the product program.

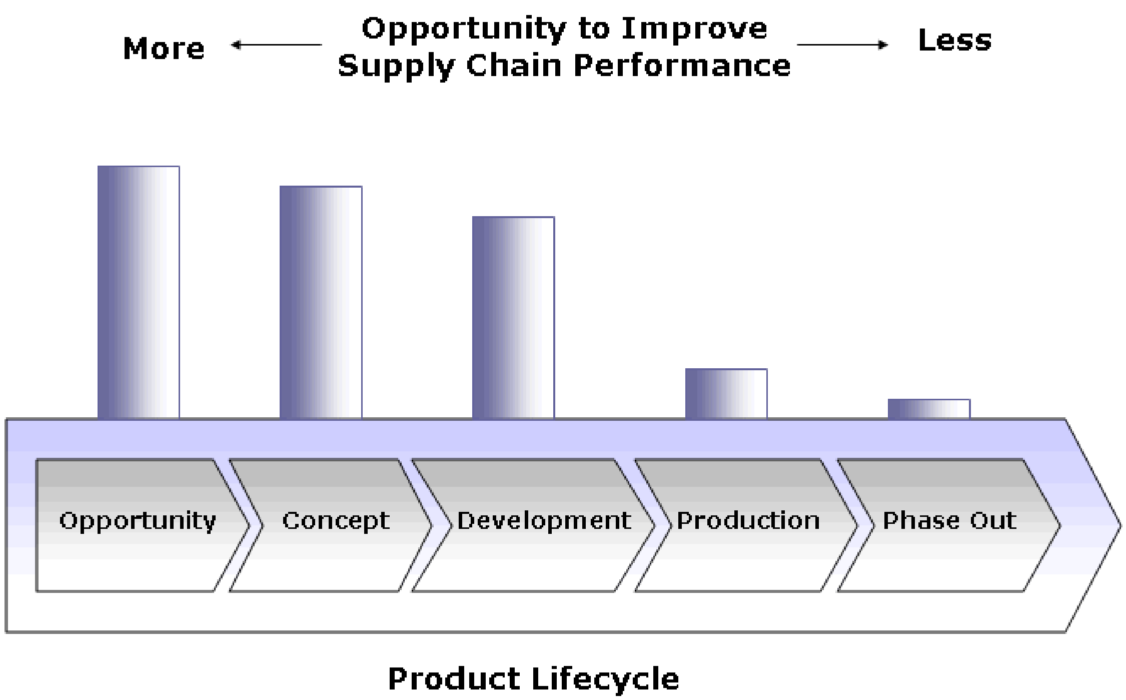


Figure 8: Product Lifecycle

Design for Supply Chain brings together all of these different processes so that supply chain performance can be evaluated throughout the product development phase. A top-down approach would be implemented as shown in the figure below.

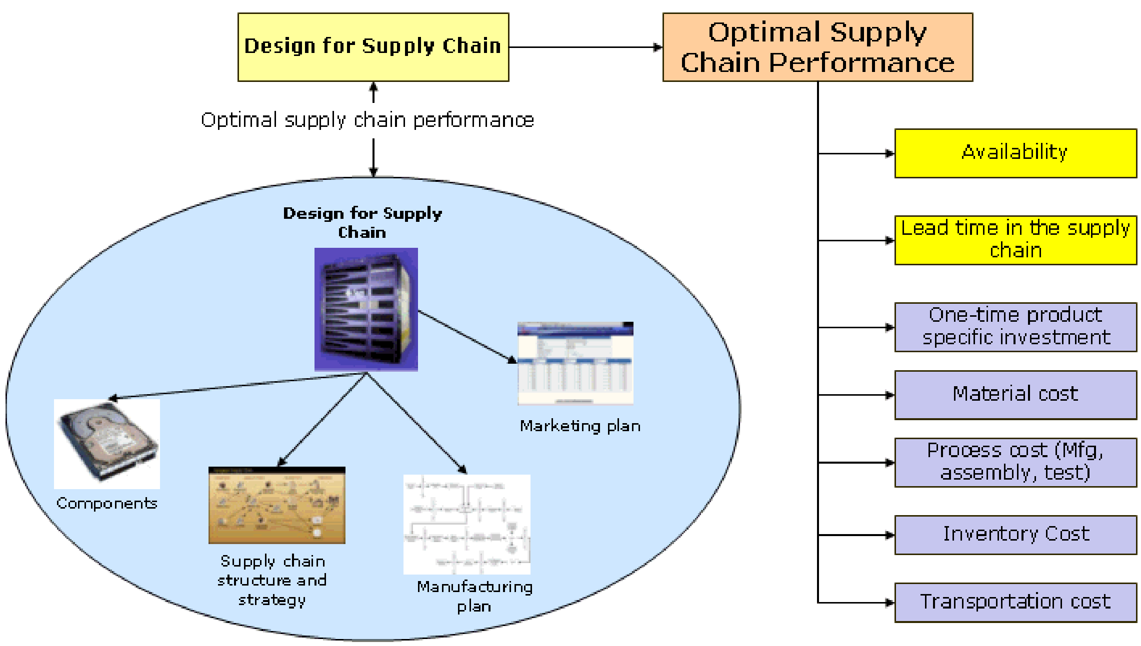


Figure 9: A top-down approach to "Design for Supply Chain"

The process and system should offer necessary data input mechanisms or interfaces with operational systems such as PLM and Supply Chain Planning systems, where relevant data may be available.

"Design for Supply Chain" Process and System Requirements

As mentioned earlier, "Design for Supply Chain" is a process that is inherently cross-functional and requires involvement of marketing, engineering, finance, manufacturing and supply chain team members. For each of these team members to offer inputs to the process or system, the process should also offer sufficient benefit, usually by way of offering good estimates of performance metrics that are important for them. Fortunately, Design for Supply Chain process offers useful information (availability, lead time and total cost) that is important for all groups related to the product program.

One of the easiest ways to obtain necessary information is to provide spread sheet templates that users can use to provide inputs to the process. Another mechanism is to offer web based input mechanisms that users can use to enter the information. However, by far the most effective approach is to integrate with native systems that are used by different team members (SRM, SCP/M, Mfg planning, etc.) and extract the required data automatically. The last method has the benefit of allowing users enter information in the systems that they normally use.

From an Information Systems perspective, the process could be deployed using Off-the-shelf computing systems such as J2EE application servers, Relational Databases, data warehousing, EAI and discrete event simulation. We developed the "Design for Supply Chain" on a commercial composite application development and deployment platform. A composite application development and deployment platform offers a rapid approach for developing and maintaining cross-functional applications by offering useful services (object management, data transformation, business intelligence, application integration, GUI development) in an integrated manner.

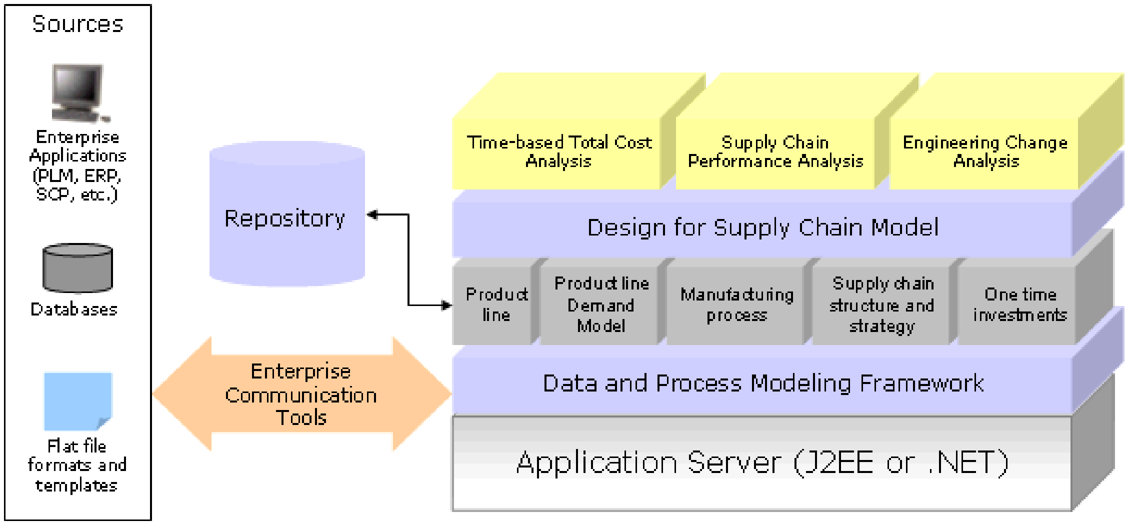


Figure 10: IT infrastructure for "Design for Supply Chain" Process

Finally, the "Design for Supply Chain" process and system that we developed also gave us the ability to extend the process and applications to suppliers and customers and use it as an operation tool to support sustainment. In that case the primary use of the process and system would be for real time visibility into supply and demand across the network and implementation of cross-enterprise business processes.

"Design for Supply Chain" and Engineering Change Management

Engineering change management continues to be one of the most complex processes to implement effectively in global supply chains. This is especially so in high tech electronics vertical where the industry structure is highly horizontal and many of the manufacturing and supply chain activities are performed by different companies in the value chain.

Engineering changes are primarily executed to continuously improve products or to respond to an urgent situation such as a field failure, safety problem or supply chain disruption.

Source of Engineering Changes

- Design or process change to respond to failure or disruption
- Design or process change to support continuous improvement

One of the fundamental challenges of engineering change management is the proper implementation strategy such that there is effective reduction in total cost or increase in revenue. Poor implementation may result in miscommunication, overall supply chain performance degradation and increase in total cost.

We have integrated the "Design for Supply Chain" into the engineering change management process so that all engineering changes (those that are not safety critical) are evaluated to see if they bring about improvement in supply chain performance. In addition, it ensures that total cost of implementation (by considering inventory write-off loss in the supply chain, cancellation cost of confirmed POs, etc.) does not exceed the benefit that can be obtained by implementing the engineering change. The following figure shows a representative total cost analysis of an engineering change

Change Analysis - Escape change over to NiCAD batteries

New Product	Escape Hybrid B
Old Product	Escape Hybrid A
Unused Parts	200V-Lead-Acid-Battery-Pack
Recommended Cutover In	Period 3

Period	Date	Profit for New	InventoryWriteOff	Net Profit for New	Profit for Old
1	2003/07/01	2,549,998.00	8,000,000.00	-5,450,002.00	20,524,998.75
2	2003/08/01	8,074,997.00	7,000,000.00	1,074,997.00	14,819,999.00
3	2003/09/01	21,349,994.00	6,200,000.00	15,149,994.00	9,614,999.25
4	2003/10/01	20,337,494.50	5,600,000.00	14,737,494.50	5,409,999.50
5	2003/11/01	21,124,995.00	5,200,000.00	15,924,995.00	2,104,999.75
6	2003/12/01	24,564,994.20	5,000,000.00	19,564,994.20	2,104,999.75
7	2004/01/01	19,124,995.00	4,800,000.00	14,324,995.00	1,683,999.80
8	2004/02/01	15,912,495.50	4,640,000.00	11,272,495.50	1,683,999.80
9	2004/03/01	12,899,996.00	4,480,000.00	8,419,996.00	1,262,999.85
10	2004/04/01	11,294,996.20	4,360,000.00	6,934,996.20	1,052,499.88
11	2004/05/01	10,087,496.50	4,260,000.00	5,827,496.50	1,052,499.88

Figure 11: Engineering Change Analysis on the basis of total cost

In addition, the "design for supply chain" process and system can also solve the pain points that high tech industry members face related to engineering change management

- Communicating the design change through out the supply chain (change propagation)
- Failure analysis
- Managing a supply disruption (robust design for supply chain)
- Evaluation of strategies to handle component End-of-life (EOL)

Implementation of Design for Supply Chain

The implementation of "Design for Supply Chain" will bring another facet to product development that is not present in the current product development activity. Current product development processes, while cross-functional, are mostly concerned with developing a product line to meet form, function, performance and basic cost targets. The manufacturing and supply chain planning process is mostly concerned with bringing the product to market on time in an efficient manner.

Design for Supply Chain process brings the facet of supply chain performance as an important metric to manage as part of the product development process. It is a metric just as important as form, function and performance of the product line. And the responsibility of managing this metric lies on the whole product team, which includes marketing, finance, engineering, manufacturing and supply chain team members. It is essential that cross-functional team members buy off on this metric and engage proactively to improve the metric throughout the product lifecycle.

The implementation of Design for Supply Chain system can be completed in multiple phases to ensure that cross-functional team buys off on the system. A phased implementation also gives the project team opportunities to learn, improve and train cross-functional team members before pushing advanced aspects of simulation and analysis for "Design for Supply Chain"

Phase I – Development and Deployment of "Design for Supply Chain" Model

During the first phase of "Design for Supply Chain" process and system deployment the main focus should be on developing the product supply chain and financial model that can be used by cross-functional product team. As discussed earlier, the inputs to this model come from individual team members either by way of spread sheet templates, web-based input and integration with operational systems.

Phase II – Analysis and Simulation

The second phase of the simulation involves deployment of analysis and simulation procedures that offer continuous visibility into supply chain performance as the product development, manufacturing planning and supply chain development activities progress. The analysis and simulation can include basic and advanced techniques such as

- Time based Profit and Loss Statement for the Product Line (For accurate total cost calculation)
- Supply Chain Analysis using non-linear optimization techniques (to find out the right supply chain structure and strategies that meet the supply chain performance target)
- Discrete event simulation of the complete supply chain (for simulating the end-to-end supply chain and evaluating its performance)
- Engineering Change Analysis (to evaluate the impact of engineering changes on supply chain performance)

Phase III – Continuous Improvement

Phase III is concerned with using the Design for Supply Chain process and system for supporting a continuous improvement program for the product line. Since the process and system analyzes and quantifies design, manufacturing and supply chain factors in terms of supply chain performance, it would easy to establish a monitoring system that would compare operational metrics with those obtained from "Design for Supply Chain" process and analysis.

Phase IV - Connectivity

In the final phase it is possible to use the "Design for Supply Chain" system to connect to supply chain partners. If the firm does not currently have any process or system that offers real time visibility into demand and supply, an extension of Design for Supply Chain system can be used to support operational supply chain processes.

Training Needs

"Design for Supply Chain" process requires that the cross-functional product team complete preliminary training in the subjects of finance, manufacturing and supply chain management.

Metrics

Implementation of any new process or a system should include thorough measurement of improvement that it brings about for the firm. Fortunately for Design for Supply Chain the metrics are quite easily seen on the product and loss statement for the product line.

It is also important to establish an ongoing program to compare the actual performance of the supply chain to evaluated performance obtained from the "Design for Supply Chain" process. An example of such a comparison is shown below.

	Launch Preparation	Jan, 2004		Mar, 2004		July, 2004	
Target Lifecycle Cost Management	Target	Target	Actual	Target	Actual	Target	Actual
Profit Contribution	-15.695.600.00	6.465.792.00		9.446.472.00		3.485.508.87	
Revenues	0.00	44,700,000.00		59,600,000.00		33,618,125.00	
Price		149.00	149.00	149.00	148.00	134.47	135.00
Total Volume		300,000	280,000	400,000	375,000	250,000	275,000
Total Revenues	0.00	44,700,000.00		59,600,000.00		33,618,125.00	
Costs	15,695,600.00	38,234,208.00		50,153,528.00		30,132,616.13	
DP100							
Material cost		105.00		104.00		100.60	
Processing cost		14.00	14.20	13.80	14.10	13.50	13.40
Transportation cost		3.00	3.10	3.00		3.00	
Service/Warranty cost		894,000.00	900,000.00	953,600.00	1,000,000.00	369,799.38	350,000.00
Poor quality (scrap, rework) cost		157,500.00	150,000.00	174,720.00	150,000.00	100,600.00	100,000.00
Investment cost	12,000,000.00						
Inventory holding cost	40,000.00	31,500.00	40,000.00	41,600.00	38,000.00	25,150.00	25,000.00
Inventory write-off cost	400,000.00	357,600.00	400,000.00	417,200.00	375,000.00	201,708.75	210,000.00
Expedited shipment cost		10,000.00		10,000.00		10,000.00	
Casing							
Material cost		8.00	8.08	8.00	8.00	8.00	7.90
Motherboard							
Material cost		52.00	51.80	51.00	51.20	49.00	49.00
Speaker							
Material cost		8.00	8.00	8.00	8.00	7.70	8.00
Antenna							
Material cost		10.00	10.00	10.00	10.00	9.70	9.75
Battery							
Material cost		12.00	12.00	12.00	11.80	11.70	11.70
LCD Panel							
Material cost		15.00	15.00	15.00	15.00	14.50	14.60
Total Costs	15,695,600.00	38,234,208.00		50,153,528.00		30,132,616.13	

Figure 12: "Design for Supply Chain" Operational Measurement System

Such a measurement system also forms the basis for continuous improvement throughout the product lifecycle.

Summary

Incorporation of "Design for Supply Chain" into the product development process offers an opportunity to design superior supply chain performance into a product line at a time when it is easiest and large increases are possible. Any increase in supply chain performance should result in reduced total cost and increase in profits.

Design for Supply Chain is possible now more than ever because of easy connectivity and widespread availability of computing power to make realistic analysis and simulation possible throughout the product lifecycle.

The cross functional nature of "Design for Supply Chain" process highlights the impact of product design, manufacturing and supply chain strategies on product profitability, there by increasing cooperation among product team members towards the shared goal of improving operational performance.

In summary, "Design for Supply Chain" is a process that can increase a firm's competitive advantage in its industry.

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