Re-Architecting the Failure Analysis Supply Chain

By

Tejaswini Hebalkar

Bachelor of Science in Electrical and Computer Engineering, Carnegie Mellon University (2000)
Master of Science in Electrical and Computer Engineering, Carnegie Mellon University (2001)

Submitted to the MIT Sloan School of Management
and to the Engineering Systems Division
in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
and
Master of Science in Engineering Systems
in conjunction with the
Leaders for Manufacturing Program
at the
Massachusetts Institute of Technology
June, 2007

Signature of Author ______________________________
MIT Sloan School of Management & MIT Engineering Systems Division
May 11, 2007

Certified by ______________________________
Deborah J. Nightingale, Thesis Supervisor
Professor of the Practice, Dept. of Aeronautics and Astronautics and Engineering Systems Division

Certified by ______________________________
Sara L. Beckman, Thesis Supervisor
Senior Lecturer, Haas School of Business, University of California, Berkeley

Certified by ______________________________
Donald Rosenfield, Thesis Reader
Senior Lecturer, MIT Sloan School of Management & Director, Leaders for Manufacturing Program

Accepted by ______________________________
Richard de Neufville
Professor of Engineering Systems & Chair, Engineering Systems Division Education Committee

Accepted by ______________________________
Debbie Berechman
Executive Director of the MBA Program, MIT Sloan School of Management

This page is intentionally left blank

Re-Architecting the Failure Analysis Supply Chain

By

Tejaswini Hebalkar

Submitted to the MIT Sloan School of Management
and to the Engineering Systems Division
at the **Massachusetts Institute of Technology**
on May 11, 2007
in Partial Fulfillment of the Requirements for the Degrees of
Master of Business Administration
and
Master of Science in Engineering Systems

Abstract

With customer satisfaction and lifecycle product quality becoming a competitive advantage, technology companies are motivated to look beyond their historical focus on forward supply chain management. Operational excellence in customer returns management, failure analysis, and closed loop corrective action is taking on an increasingly important role as companies strive to improve their business processes, policies and supply chains to achieve a world-class leadership position in their industry.

In the competitive high-tech industry, companies face a number of challenges in managing customer returns and re-architecting their failure analysis supply chains to support a closed loop corrective action approach to product quality. Supporting globally distributed customers through a diverse network of outsourced manufacturing, repair, failure analysis and logistics partners increases the complexity of the supply chain architecting problem. This thesis proposes a holistic enterprise architecting approach, including governance, process, network design, organization, enabling technology, and performance management elements that should be considered when re-architecting the failure analysis supply chain. During this process, strategic decisions need to be made regarding supply chain designs that are aligned with the vision of the enterprise. Operations managers and leaders can use data-driven, collaborative approaches supported by decision support tools like the "Decision Model for Failure Analysis Supply Chain" to align decisions with customer value and stakeholders' needs.

Implementing changes based on these strategic decisions requires understanding organizational dynamics within the enterprise. An understanding of the "frame of reference" that guides decision makers can help address implementation challenges. In addition, communication, training and alignment of incentives across functional groups to encourage collaboration can allow enterprises to make strategic decisions that are successfully implemented. The strategies proposed in this thesis are intended to aid managers in making monumental changes to their "reverse" operations and exceeding customer expectations.

Thesis Supervisor: Deborah J. Nightingale
Title: Professor of the Practice, Dept. of Aeronautics and Astronautics and Engineering Systems Division

Thesis Supervisor: Sara Beckman
Title: Senior Lecturer, Haas School of Business, University of California, Berkeley

Thesis Reader: Donald Rosenfield
Title: Senior Lecturer, MIT Sloan School of Management & Director, Leaders for Manufacturing Program

This page is intentionally left blank

ACKNOWLEDGEMENTS

I wish to acknowledge Cisco Systems, Inc. for supporting the Leaders for Manufacturing (LFM) Program internship upon which this thesis is based. In particular, I would like to thank Chuck Kolstad for mentoring, and Vah Erdekian and Jim Miller for sponsoring and championing this internship. To Rita, Justin, Jim, Steve, Nick, Naznin, Marc, Sachin, Hitesh, and the many individuals at Cisco who contributed to my learning, thank you. Interacting with you has educated me a great deal about failure analysis, quality systems, reverse supply chains and leadership in a company like Cisco.

I would like to acknowledge the Leaders for Manufacturing Program and its industry partners for supporting this research and for guiding me during my two years at MIT. I am grateful to Sara Beckman and Debbie Nightingale, my thesis advisors, and Don Rosenfield, my thesis reader, for their knowledge, advice, support and guidance of my research. I would like to acknowledge the professors at MIT who have taught me how to become a better leader. I would also like to acknowledge the current and past LFM students who contributed to my knowledge of reverse logistics and returns processes. Thank you to the friends who made my LFM experience one to remember.

To my family, I am eternally grateful for your constant support. To my parents, Shailaja and Prakash Hebalkar, you have been the giants upon whose shoulders I have stood. Your love, insight, strength and encouragement have helped me overcome all obstacles and have guided my path to success. To my parents-in-law, Rohini and Ramesh Chaware, thank you for your love and support. To my best friend and husband, Raghunandan Chaware, thank you for being my shining star, for showering your love and affection, and always encouraging me to pursue my dreams. I am forever grateful for having you in my life.

This page is intentionally left blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. High-tech companies are looking for operational improvements

With customer satisfaction and lifecycle product quality becoming a competitive advantage, high technology companies are motivated to look beyond their historical focus on forward supply chains for improved operational and financial performance. Forward supply chain management, including inventory management and order-to-delivery logistics, has long been a focus for optimization, with problems that are well understood and improvement programs long implemented. As companies try to achieve increased operational gains from supply chain management, they are starting to look at business processes and policies related to their reverse supply chain. Operational excellence in customer returns management, failure analysis, and closed loop corrective action[1] is the new focus for companies trying to achieve competitive advantage and a world-class leadership position in supply chain management.

1.2. Reverse supply chains are often ignored in favor of forward chains

Reverse supply chain management, the process of managing the product and information flows back from customers after product delivery, was largely ignored by high-tech companies during the technology bubble in the late 1990s and early 2000s. It was more important to ship product and recognize revenues than be concerned about whether products were returned by customers. As a result, companies expended significant effort on optimizing the forward supply chains to achieve operational competitive advantage. By contrast, customer returns management and failure analysis of defective product were considered secondary and often included in the responsibilities of the forward supply chain managers and product development teams.

As technology companies begin to differentiate themselves in an increasingly competitive market, they are looking for ways to increase customer satisfaction among existing customers

[1] In this thesis, the terms "reverse supply chain", "failure analysis supply chain", "returns supply chain" are interchangeably used to describe the supply chain involved in obtaining product returns from customers, identifying the root cause for the problem and providing feedback to the customer. "Reverse logistics" is used to describe the logistics process involved in moving the product from the customer or distributor back to the manufacturer, and is considered part of the "reverse supply chain". For definitions of these terms, please refer to the Glossary in the Appendix.

and attract new customers through improved product quality. New efforts are being expended on managing the customer experience during product return, exchange and repair, and on closing the feedback loop between failure analysis (the process of fault detection and root cause analysis for a defective product) and design of the next generation product. Technology companies are starting to separate returns management and failure analysis groups from their traditional homes in forward supply chain and development organizations to allow for focused efforts on operational improvements. As the vice president of operations and administration at Olympus Imaging America Inc. acknowledges, the company needed to "pull the reverse [logistics] function away from the supply chain and distribution operations in order to be able to give [it] the required attention."[2]

1.3. Returns management can become expensive for high-tech companies

Technology companies starting up returns management and reverse logistics groups are beginning to recognize how these functions directly affect their bottom-line financial measures. The Reverse Logistics Executive Council estimates that reverse logistics costs account for approximately 0.5% of the total United States' GDP.[3] In a recent benchmark survey of 175 companies, Aberdeen Group, an industry research analysis firm, found that among companies that measured their reverse logistics costs, between 9% and 14.6% of their revenue was spent on managing reverse logistics.[4] As many as 93% of their survey respondents were not even aware of the impact that reverse logistics costs had on their bottom-line. Another benchmark report on warranty management by the Aberdeen Group indicated that even best-in-class high-tech manufacturing companies spend over 3.7% of their revenues on warranty claims as shown in Table 1. Based on these statistics, a large company like Cisco Systems with 2004 product revenues of $20.9 Billion might have spent over $700 Million on warranty claims alone during that year. With such a significant impact on a company's bottom line, it is no wonder that

---

[2] Quoted in Gecker, R., and M. W. Vigoroso. Revisiting Reverse Logistics in the Customer-Centric Service Chain. Aberdeen Group, 2006. <http://www.aberdeen.com/summary/report/benchmark/RA_RevLogReport_RG_3475.asp>.
[3] Reverse Logistics Executive Council. Feb 1, 2007. <http://www.rlec.org>.
[4] Gecker, R., and M. W. Vigoroso. Revisiting Reverse Logistics in the Customer-Centric Service Chain. Aberdeen Group, 2006.

companies like Olympus and Cisco are starting to look at ways to optimize their customer returns management and reverse logistics functions.

Performance Tier	Industry Sector	% of Products Returned w/in 1st Warranty Period	% of Revenues Spent on Warranty Claims	Claim Processing Time (business days)
1	Industrial Mfg.	4.4%	1.4%	5.5
	Aerospace & Defense	3.2%	1.1%	10.7
2	Consumer Goods	6.7%	2.5%	4.0
	Telecom/Utilities	8.4%	2.8%	6.3
3	High-Tech Mfg.	12.1%	3.7%	2.0
	Automotive	11.8%	2.0%	12.6
	Transportation/ Distribution	9.0%	2.5%	6.3
4	Medical Mfg.	4.6%	2.3%	2.9

Source: AberdeenGroup, June 2006

Table 1: Best-in class high-tech companies spend 3.7% of their revenues on warranty claims

1.4. Thesis provides insights into failure analysis supply chain challenges

This thesis will first review the basic concepts in returns management and failure analysis and describe the challenges currently faced by high-technology companies in managing and optimizing their failure analysis supply chains. Next, strategies for improving the failure analysis supply chain will be discussed. The thesis will then introduce a holistic approach to re-architecting the failure analysis supply chain and making complex decisions involving multiple stakeholder groups. This will include a review of reverse supply chain best practices that managers and organizations can apply to their specific challenges to achieve operational excellence. Finally, the thesis will describe some of the implementation challenges that high-tech companies face when re-architecting the supply chain and executing on their vision. This thesis is based on an internship conducted at Cisco Systems, Inc. as part of the Leaders for Manufacturing Program at MIT. The Cisco context will be used as a case study to highlight some of the problems and challenges and share insights learned during this internship. The intent of this work is to highlight the failure analysis supply chain challenges faced by technology companies and identify strategies to overcome these in an effective manner.

Chapter 1 presents an introduction to the industry context that should motivate technology companies to focus attention on the problems faced by the failure analysis supply chain. Each of the remaining sections of the thesis builds upon the prior section, walking the reader through a step-by-step approach to understanding the problem, identifying the vision, developing the failure analysis supply chain architecture, evaluating alternative designs and addressing challenges during implementation of a new architecture. Chapter 2 highlights the problems faced by typical high-tech firms in their global failure analysis systems. Chapter 3 presents an approach to defining the vision for a new, improved failure analysis system. Chapter 4 introduces an enterprise architecting framework for developing a new failure analysis system. Chapter 5 discusses a decision making model that could be used by the architecting team to evaluate alternative supply chain designs. Chapter 6 discusses some of the implementation challenges faced by companies trying to institute change within their enterprises. Finally, Chapter 7 summarizes some recommendations that will help managers overcome the problems and challenges discussed throughout this thesis. References used in this thesis are included in Chapter 8, while the Appendix (in Chapter 9) includes background on Cisco Systems, the detailed Reverse Supply Chain Best Practices Framework, an example of a Diagnostic Tool based on the best practices framework, details on the Decision Model that was developed, and a description of the research methodology used during the LFM internship.

2. UNDERSTANDING THE PROBLEM

2.1. High-tech product companies need to understand returns management and failure analysis

High-tech companies like Cisco provide sophisticated products to their telecommunications customers like AT&T and Verizon and to end-consumers like you and me who might purchase a wireless router or cable-box. These products may be shipped from one of the company's manufacturing partners like Solectron to its warehouses, to distributors, to customers or to retail stores where consumers can purchase products off the shelf. The complex system of partners, sites, processes and people that manage products being returned to Cisco constitute the company's "returns management system". The logistics process involved in returning these products to the company after sale or delivery to the customer is called the "reverse logistics" process.

There are several reasons why customers and downstream supply chain partners may return products. For example, customers may return products when:

i) the products were not what they had ordered or did not meet their expectations,
ii) the products they received were defective or damaged when they received them,
iii) the products failed during operation or prior to the end of the warranty period,
iv) the products reach the end of their lease term,
v) the company decides to recall the products for safety reasons,
vi) the company agrees to reuse, recycle or dispose the products in compliance with local laws and environmental regulations (e.g., European Union laws requiring proper disposal of electronic goods by the manufacturer or company selling the product).[5]

In addition, there may be other reasons why products get returned to the manufacturer by the downstream supply chain partners. For example, some companies may have marketing arrangements or inventory re-balancing programs with their retailers or agree to accept excess end-of-season returns of consumables.

---

[5] Bowers, B. "Enhancing The Lean Enterprise Through Supply Chain Design: Establishing Reverse Logistics And Remarketing At A High Tech Firm." MIT LFM Thesis. 2003.

If products are returned due to damage, defects or operational failures, it is important for companies to understand the root cause(s) for this failure. The process of diagnosing faults within the returned units and determining root cause(s) is called “failure analysis”. The complex network of sites, partners, IT applications and processes that supports failure analysis is called the “failure analysis system”. Failure analysis often involves visual inspection of the returned unit, mechanical and electrical testing of the part and sometimes disassembly to identify and evaluate the cause and severity of the failure. By understanding the nature of the product failure, the repair organization can correct the fault with the unit and either return the unit to the customer or hold the unit as a replacement for another warranty situation. High-tech companies can provide feedback to the development organization to prevent or reduce the effects of such problems in future designs of the product. This feedback can also be provided to the service and technical assistance organizations to help them identify and possibly prevent similar problems from arising with other customers. In some cases, contracts with the end customer (like AT&T) may require the manufacturer to provide information on the root cause of the problem to ensure that the customer’s network of telecommunications equipment does not disrupt the phone, internet and wireless connectivity of thousands of end-consumers. This process of understanding the root cause of failure, correcting the fault, and feeding information back to the other parts of the organization and customers is often referred to as “closed-loop corrective action”.[6]

2.2. Failure analysis systems in high-tech industries can be complex

A typical high-tech company like Dell or Cisco designs and sells several types of computing systems consisting of multiple components. The high-level product and information flows for a simple failure analysis system may be similar to the one shown in Figure 1 below. When a customer discovers a problem with the product, (s)he calls the company’s Technical Support Center, where a consultant (who may be an engineer or call center representative trained in product functionality) handles the customer’s call and tries to diagnose the problem remotely. If the problem can be diagnosed, the consultant completes the call and “logs a case” to document the details. If the problem needs further analysis, the consultant “opens a case” and provides

[6] The terms “failure analysis” and “closed-loop corrective action” will be used interchangeably within this thesis to refer to the entire process of fault diagnosis and feedback to customers and other parts of the company. For definitions refer to the Glossary in the Appendix.

details to the Reverse Logistics group regarding the product that needs to be returned. The Reverse Logistics group then communicates shipping details to the customer, which may involve return instructions, a Return Material Authorization (RMA) allowing the customer to return the unit for credit or replacement and packaging materials. The customer ships the defective product back to the high-tech company's Reverse Logistics group. This group receives the product at a returns depot, then forwards the product to the Failure Analysis site, and provides a shipping notification. The Failure Analysis (FA) site diagnoses the fault and provides detailed information to the group within the high-tech company that handles the reporting to customers (often Quality or Sales). The Quality (or Sales) group then generates a failure analysis report which is provided to the customer describing the specific cause of the failure. This report may also be shared within other parts of the company like the development and services organizations. The high-tech company also makes a decision on whether the returned product should be repaired or disposed.

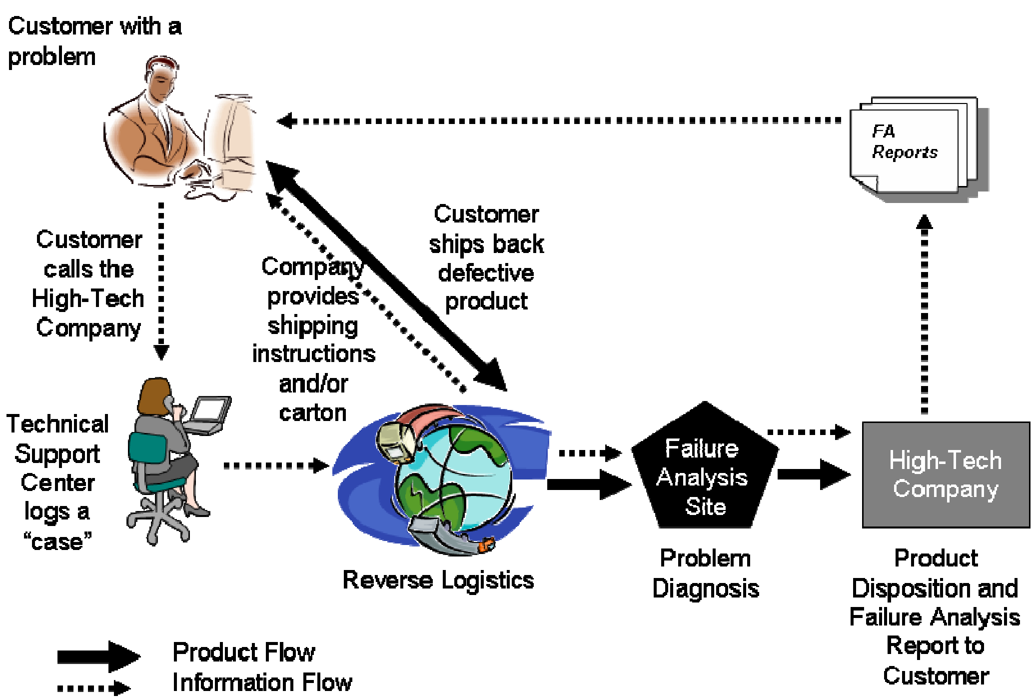

Figure 1: Typical product and information flows in a Failure Analysis System

This process flow shown in Figure 1 is a very high level depiction of a failure analysis system. In most high-tech companies, there are a number of factors that complicate the flow. The major complexity factors observed in large, global companies include:

i) multiple products and product families
ii) geographically dispersed customers and downstream supply chain partners
iii) multiple sites and outsourced partners in various geographic locations
iv) multiple tiers of failure analysis sites
v) inadequate gatekeeping information for determining validity of returns
vi) disparate systems to handle information

These factors are discussed in further detail below and the complexity of product and information flow is depicted in Figure 2 at the end of this section.

2.2.1. Product Variety

Consider a company like Dell which has a broad variety of products and product families including desktop computers, laptop computers, servers, handheld PDAs, printers, TVs etc. Within the desktop computers product type, there are a number of product families like Dimension, Optiplex and XPS. Each product family may have different product models having different components and configurations. In theory, Dell will need to maintain product specifications, technical support requirements, repair guidelines and failure analysis test scripts for each of the models. Sometimes, companies like Dell can develop standard platform architectures for the models that minimize the need for unique information for each product and allow some common use. However, in many situations, testing and failure analysis for desktop computers will be different from that of TVs or laptop computers. As a result, Dell will need to manage the complexity of multiple types of failure analysis at the failure analysis sites. In addition, the shipping size and requirements of each type of product may be different and the company will need to be able to handle the return of all of the varieties of products it carries in its portfolio.

2.2.2. Geographic Diversity

In this age of globalization, high-tech companies cater to the needs of customers in a number of countries and regions around the world. As a result, they can expect returns of products from the same customers located around the world. Companies need to put in place systems and infrastructure to be able to handle such global diversity of their customers. For example, a high-tech company might need several technical support centers staffed by regional-language speaking consultants in multiple locations in the world. Their reverse logistics processes need to support shipping of products back from customers to a central returns depot or to multiple regional depots where the returns can be processed. Shipping instructions may vary for different types of customers or supply chain partners (e.g., retail stores may return end-of season items in bulk) and for customers returning products from different regions (e.g., due to customs regulations or regional laws). In some cases, the return depots may be geographically dispersed, causing the product and information flows to be further complicated (making this a many-to-many network).

2.2.3. Outsourcing

While some companies (like Dell) manufacture their own systems, others (like Cisco) outsource the manufacturing to third party firms called “contract manufacturers”. High-tech companies may also outsource the logistics processes to other companies like FedEx or UPS and use distribution warehouses owned by third party logistics providers (called “3PLs”). Similarly, the failure analysis and repair operations may also be outsourced to “contract failure analysis” providers and “contract repair” companies. Call centers for technical assistance and field service personnel may be managed by third parties. In such an environment, there may be multiple outsourced partners involved in the Failure Analysis System, each with their own operating guidelines. Each firm may have locations and operations in multiple geographical locations. As is the case with many global companies, such firms may continue to maintain different processes in different regions of the world. Managing such a complex supply chain network poses an interesting challenge to high-tech companies that historically managed their warranty operations internally. Even if these companies have successfully managed forward supply chains (for manufacturing and delivery to customers), the product and information flows in the reverse direction are different and may result in added management complexity.

2.2.4. Multi-Tier Failure Analysis

Product complexity contributes to the diverse product flows that occur in a failure analysis system. For example, a simple product like a phone may have fewer components that could fail and require less sophisticated failure analysis. On the other hand, a central office switch that handles thousands of phone calls at a time may have many more failure modes. In such sophisticated products, knowledge of the operating conditions under which the switch failed may also be important to diagnose and fix the failure. Sometimes, a cursory inspection may point to areas for further investigation, while in other cases extensive testing will be required to select possible areas for detailed diagnosis. The technical capabilities of the failure analysis sites and outsourced contract failure analysis providers may differ from location to location and in some cases be inadequate to diagnose the root cause for more complex products. In such cases, it may be necessary for the initial failure analysis site (i.e., the 1st tier failure analysis site) to send the product to another location such as the high-tech company's internal failure analysis lab, a specific business unit's lab or a third party Original Equipment Manufacturer (OEM) that designed and manufactured the product for the high-tech company. These constitute 2nd tier failure analysis sites. As one can observe, the failure analysis network continues to get more complex, with decisions required at each step to determine where to send the product and information next.

2.2.5. Inadequate Gatekeeping Information for Returns

The process of managing the point of entry into the returns management system is called "gatekeeping". Gatekeeping involves understanding the reason why the customer is returning the product, only allowing products with valid problems and warranty coverage to be returned by customers, and collecting adequate information regarding the returned product to allow the company to process a replacement claim or provide proper credit to the customer. Many firms fail to put into place guidelines for gatekeeping, leaving the technical assistance centers and reverse logistics groups to handle significantly more calls and product returns than would be profitable for the company. In some cases, even with gatekeeping guidelines, the subjectivity of the person "logging the case" may be involved in processing the returns. If a customer is extremely irate, a new customer service representative may be more concerned about pleasing the customer than following strict guidelines. They may allow the customer to return the product, regardless of the customer's eligibility to return the product under warranty terms. In other cases, customers may not provide adequate information for processing the returned product when it is received by the company's reverse logistics group. For complex products, inadequate information relating to the operating conditions that cause the product to fail often causes failure analysis sites to spend unnecessary time trying out unlikely scenarios, resulting in non-value added work. Thus, adequate objective gatekeeping information is important for profitably managing the returns operation.

2.2.6. Disparate Information Systems

Companies today manage large amounts of information relating to design, manufacturing, logistics, failure analysis, quality and returns. In most companies, the information relating to various functions and processes resides in different information systems and applications. In an outsourced, geographically dispersed supply chain network, this disparity is exacerbated, as each firm and location manages its own information. Information systems often do not have adequate connectivity, requiring human intervention to transfer data from one system to another. Several problems can arise with disconnected information systems. For example, the contract failure analysis site may not have access to design and manufacturing information that may be useful to diagnose a fault, the reverse logistics provider may not have warranty information for a customer or forwarding information for a failure analysis site, or the company may not have product visibility throughout the process due to inadequate information flows between systems. This may lead to significant personnel involvement to transmit data and information relating to the returned product through manual reports or email, resulting in lost productivity, frustration and non-value added work. As high-tech companies are beginning to realize, the presence of multiple, disparate, manual systems is one of the major challenges that must be addressed to improve operational efficiency of their processes and profitability of their business.

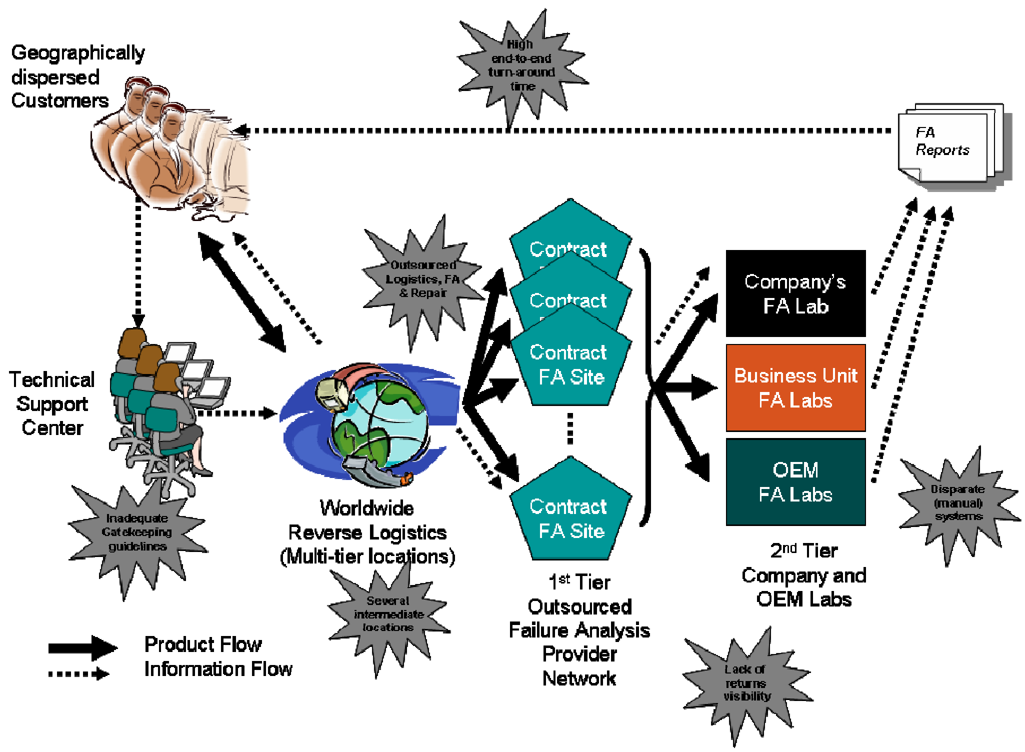

Figure 2: Complexity of product and information flow in a Global Failure Analysis System

2.3. Complexities in current Failure Analysis Supply Chains affect operational and financial performance

Global failure analysis systems require a number of returns related processes to support them. In addition, unanticipated returns from customers place additional burden on the already complex failure analysis processes in place at many corporations. The complexity of maintaining global failure analysis processes shown in Figure 2 and described in section 2.2 results in a number of problems affecting operational and financial performance of firm as described below.

2.3.1. High Turnaround Time

The number of steps that products and information have to flow through in current Failure Analysis Supply Chains is significant. At each stage of the supply chain (e.g., at Technical Support Center, within the Worldwide Reverse Logistics System, at Contract FA sites, at 2^{nd} tier FA sites etc.), returns may have to wait to be processed and forwarded. For example, the consultant at the Technical Support Center may need to validate the customer's eligibility under warranty, identify the issue that the customer is facing and manually enter the information in an information system before a case can be logged. In another stage, when the reverse logistics depot receives the product back from the customer, it may sit on the dock prior to being received and processed. With multiple, manual information systems, these delays can be exacerbated. Geographic disparity of customers and FA sites can also aggravate the delays if customs clearances take time. Inadequate gatekeeping guidelines and differing skill levels of outsourced partners could increase the turnaround time even more between customers sending the products back and receiving feedback on the root cause of the problem. Depending on how complex a company's Failure Analysis supply chain really is, the turnaround time for the same type of products could range from a few days to several months. For example, at Cisco, the customer perceived turnaround time was significantly higher than expected, with a third of this time taken up by the initial stages of the returns process from case creation to part receipt at FA site (marked as X days in Figure 3 below).

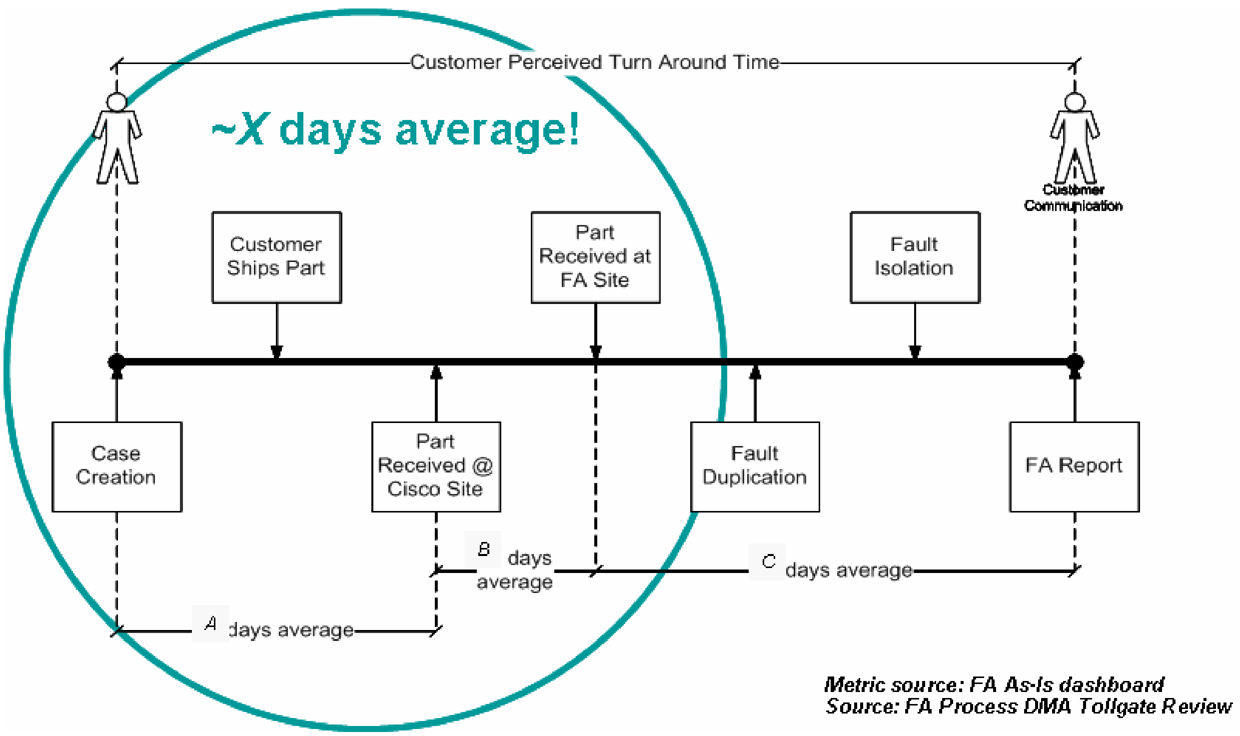

Figure 3: Customer perceived turnaround time can be longer than expected at Cisco

2.3.2. High Cost

Complex failure analysis supply chains can involve a wide range of policies and handling processes for returns. Manual processing incurs more labor costs than use of automated systems. Shipping from multiple locations and through multiple intermediate stages can increase transportation costs. In addition, with outsourced partners managing returns in different stages and geographies, coordination costs relating to failure analysis returns can increase. Diagnosis costs can differ from location to location and complexity of products can result in higher costs. Furthermore, exceptions that need to be handled due to human error or inadequate gatekeeping can also increase overall costs of failure analysis for the company.

2.3.3. Inadequate Product and Information Visibility

One of the primary challenges facing companies today is the inability to track returns through their supply chain. In more sophisticated returns management processes, when a customer ships back a product, they usually include a piece of paper called the "Return Material Authorization" (RMA) sent to them by the company. This RMA is the usual tracking mechanism for returned products. In many instances, customers do not inform the company to which they are returning the product when they actually ship the product. Similarly, the 3PL who handles the logistics may not have a mechanism for tracking shipments in-transit. In cases where logistics providers do provide a tracking mechanism, automated alerts may not be generated for the destination. As a result, returns could arrive unannounced at the receiving dock of the returns depot. Even if shipments arrive in batches (for example, if they were shipped from an international consolidation center), the mix of products being returned may be unknown. In most companies, several hours of manual processing are required to adequately receive and process the returns. If the volume of shipments was over the normal receiving capacity of the depot, the pallets of boxes may sit on the dock for several hours or days before personnel are available to process them. If inadequate information was provided on the shipping label or the RMA, the receiver may need to track down the source and eligibility of the return. Furthermore, most failure analysis shipments are sorted, opened and the actual product scanned before the receiving process is complete. Thus, it takes time and significant human involvement to properly process the returns.

Figure 4: Identifying and processing returns can be challenging without adequate information

After shipments are received and sorted, they may be held in a waiting area or in a warehouse or processed for forwarding to a failure analysis site (Figure 4). While some companies use warehouse management systems from software vendors like Manhattan Associates, Red Prairie and Infor, most companies do not have sophisticated software to support the returns management processes. As a result, tracking the boxes in the warehouse or waiting area may also require manual tracking and additional labor. When the shipments are processed and forwarded to the FA site, the returns depot may stop tracking the product as it "leaves their jurisdiction". If something happens to the shipment or it gets delayed, it becomes the responsibility of the destination organization to track the shipment. If the delays are significant, the turnaround time and costs increase and products could become obsolescent. Without adequate tracking of the product and lack of information availability, the company may not even know what the obsolescence date is for the product. Even if post-FA, the product might have been able to be repaired and returned to the spare parts stock, with processing and transit delays, product obsolescence could result in lost value from the return.

2.3.4. Inadequate Capabilities of Partners

Within a complex, global failure analysis supply chain, outsourced partners handling gatekeeping (technical support), logistics and failure analysis have differing skill and capability levels. In some cases, language barriers may cause interpretation problems, while in other cases, training level and sophistication of the workforce may be different. While some outsourced partners may have sophisticated information systems to track product information, testing guidelines, manufacturing specifications etc., other firms may not have that level of information and may have to rely on the innate skills of their labor force. Without adequate information, even sophisticated FA sites may be unable to accurately diagnose the fault with the product. If the products are complex and operational environments could affect their performance, inadequate technical support information from the customer about the product's use may also result in inadequate diagnosis of the fault and root cause of the failure at the 1st tier FA site. As a result, the 2nd tier FA sites will become overburdened with cases and operational metrics for those sites would be severely affected. The company may not be able to handle that backlog and may be forced to keep customers waiting for responses or hire additional engineers at a significant cost to support the 2nd tier FA sites.[7]

2.3.5. Customer Dissatisfaction

The biggest challenge facing companies that operate complex, global failure analysis supply chains is customer dissatisfaction. In general, customers are very concerned about problems faced when operating high-tech products and the quality of service received during the returns process. If the returns process is poorly managed due to the number of stakeholders involved or the inadequacy of information systems to support the process, customers could easily become dissatisfied. Furthermore, long turnaround times for root cause analysis or inadequate diagnosis may affect customer's confidence in the company's other products. While such dissatisfaction is often difficult to quantify (some companies try to use customer satisfaction surveys to measure this), it could lead to lost sales and affect the reputation of the company. Dell, a market leader in computing products is acutely aware of the potential impacts of customer dissatisfaction. In August 2006, Dell had to recall thousands of Sony batteries, susceptible to fire hazard, installed

[7] 1st tier and 2nd tier FA sites were defined earlier in section 2.2.4 while discussing multi-tier failure analysis.

in their notebooks. This situation probably placed a significant burden on Dell's returns process which wasn't geared up for large quantities of product returns. In addition, it might have also affected the perception that Dell had tried to build around the value and quality of their products, had the company not acted in a timely fashion by announcing that their concern for customers' safety prompted the large scale recall of batteries.[8]

2.4. Traditional approaches to reverse supply chains can present limited solutions to address these challenges

Companies have tried to deal with the complexity of returns management and failure analysis supply chains in various ways. Some companies try to address the need for detailed information through pre-printed forms and make the returns process easier for customers. For example, Lands' End, the catalog retailer, includes return instructions in the order that the customer receives. In addition to return instructions, they include a form that is pre-printed with the customer's name, address and product purchased. The customer selects a reason for returning the product by checking a box on the form and puts it back into the original box for shipping. Pre-printed mailing labels are also provided. Customers also have access to a toll-free number for-customer support if necessary.[9] By including the form and pre-printing labels and information, Lands End obtains accurate information about the reasons for customer returning the product, reduces the necessity of customer support except for more complex cases, and simplifies the logistics and returns handling process.

Automobile and aerospace manufacturers traditionally focus on reverse supply chains as sources of spare parts that can be remanufactured and utilized. The defense industry maintains spare parts depots that are involved in managing returns, repairing them and re-introducing them into the maintenance operations. In recent years, ink jet printer cartridge and cellular phone remanufacturing has taken on increasing importance. For example, there are a number of companies that acquire older cellular phones from consumers in the US, remanufacture or repair them and donate them to battered women's shelters or non-profit organizations, or sell them in

[8] Alex Gurzen, VP of Dell's Product Group quoted in an interview in "Dell recalls 4m laptop batteries." BBC News. Aug 15, 2006. <http://news.bbc.co.uk/2/hi/business/4793143.stm>.
[9] "Guide to the Goods." Lands End Direct Marketers.1998 quoted in: Tibben-Lembke, R. S. "The Impact of Reverse Logistics on the Total Cost of Ownership." Journal of Marketing Theory and Practice 6.4 (1998): 51.

lower-income countries for a significant discount. Such returns supply chains usually involve drop-off recycling bins or locations, with the company picking up the returned products from these bins on a periodic basis and introducing them into the sales/donation stream. Some companies treat these streams as sources of additional revenue, while others simply try to recover their remanufacturing and logistics costs while recycling the products and minimizing environmental impact.

Several high-tech companies have also tried to exploit their returns supply chains for spare part sources. For example, repaired returns at Cisco are used within the services supply chain to replace products or printed circuit boards that fail during the warranty period. IBM is perhaps the most notable among high-tech companies using closed loop supply chains (i.e., the combination of reverse and forward supply chains) as sources of spare parts. The company recognizes the value of integrating product returns into the business operations. In collaboration with researchers at the Erasmus University in Rotterdam, Netherlands, IBM conducted a study using an analytical inventory-control model and simulation model that showed how procurement-costs savings outweighed reverse logistics costs when information was carefully managed. This study resulted in the adoption of new policies and decision making guidelines to recover parts from returned products in their spare parts processes, thereby reducing costs for procuring new parts.[10]

Recent focus on environmentally responsible manufacturing and green supply chains has spurred significant academic literature around these topics. In "Product recovery with some byte," White et al. (2003) present an overview of the management challenges and environmental impact of reverse supply chains in the electronics and computing industry.[11] They discuss the potential that product recovery offers to reduce environmental waste and the problems associated with energy intensive remanufacturing processes, lack of reuse and limited recycling opportunities for some materials used in high-tech products. New regulations and laws like RoHS and WEE in the European Union are requiring high-tech companies to take back products and recycle or dispose them in an environmentally safe manner. Such regulations are prompting companies to innovate

---

[10] Fleischmann, M., J. A. E. E. van Nunen, and B. Graeve. "Integrating Closed-Loop Supply Chains and Spare-Parts Management at IBM." Interfaces 33.6 (2003): 44-56.
[11] White, C. D., et al. "Product Recovery with some Byte: An Overview of Management Challenges and Environmental Consequences in Reverse Manufacturing for the Computer Industry." Journal of Cleaner Production 11.4 (2003): 445-58.

their designs to reduce the use of hazardous substances in their products, and encouraging a renewed focus on supplier partnerships for remanufacturing, development of recycling consortiums and development of consumer awareness materials about recycling and reuse. However, until high-tech companies are able to streamline their returns operations, complying with such laws and regulations will increase the cost of managing high-tech product returns without adding significant value to the companies.

2.5. Stakeholder management in failure analysis supply chains is challenging

Traditionally, companies managed failure analysis as part of their development, manufacturing or quality organizations. The logistics and supply chain functions relating to failure analysis were sometimes managed as part of the forward supply chain organization. However, in recent years with more awareness of the unique challenges presented by reverse supply chains, companies like Olympus are starting to put in place separate organizations for reverse supply chain management. Despite the separation of responsibilities, the processes involved in the reverse supply chain span customer returns, failure analysis, spare parts management and recovery and recycling. In many high-tech companies, these processes are the responsibility of multiple, independent organizations, operating in functional silos. Consider this situation within a large, global company like Cisco. Technical support and RMA authorizations are managed by one organization responsible for customer service. Reverse logistics relating to coordinating and handling the logistics of customers returning the products is managed by another group. Failure analysis and product quality are jointly handled by the product development group and the manufacturing quality organization. Repair and spare parts management is handled by another services group, while customer quality reporting and metrics are managed by the corporate group responsible for quality. Throw into this mix the involvement of the sales account managers responsible for initial sales and ongoing customer interaction, finance personnel tracking the profitability of the operation, and outsourced partners performing the logistics, failure analysis and repair. One can quickly see how many stakeholders can be involved in the failure analysis supply chain.

Without coordination among these functionally independent stakeholders, the problems within large, global reverse supply chains can become acute. Yet, most companies expect that general policies and guidelines will be adequate to help with this coordination. By using such functional silos, companies fail to recognize the value of speed and combined capability in affecting cost savings and responsiveness to customers. While the emphasis on speed and cost is apparent in forward supply chains where revenue is the constant focus of Wall Street analysts and shareholders, the apparent lack of value placed on speed of coordination is disappointing on the returns side of the business. Another problem with functional silos is the lack of ownership and alignment among the functional groups. If organizational roles and responsibilities are not clearly defined, cross-functional activities such as those involved in failure analysis will suffer from “hot-potato” behavior. Such behavior results from functional groups trying to avoid taking ownership of activities and instead trying to hand them off to another group as quickly as possible without due emphasis on completing the activity. Even if each group tries to achieve the optimal performance with respect to its own metrics, unless these metrics are aligned and emphasis is placed on managerial and individual alignment among people, performance will generally suffer in the overall reverse supply chain. Cross-functional collaboration will become necessary for companies to achieve alignment and develop working strategies to address needs and overcome problems. Managers can encourage development of working level relationships among key stakeholders to minimize the impact of organizational silos. Such relationships will bridge the collaboration gap, ensure buy-in when required for collaborative decision making, and align everyone’s expectations around successful performance. In addition, at the corporate level, high-tech companies should re-evaluate whether the distributed, functional silos are more effective at managing great supply chains, or collaborative virtual matrix structures are needed to ensure optimal reverse supply chain performance.

3. ENVISIONING THE FUTURE FAILURE ANALYSIS SUPPLY CHAIN

Ad-hoc failure analysis supply chains have cropped up in numerous high-tech companies due to historical lack of focus on returns management. The problems and challenges described in Chapter 2 serve to exacerbate the management complexity of these supply chains. As high-tech companies try to re-focus on operational efficiencies in their overall supply chain (including the reverse supply chain), it will become important to identify what value is needed from the new failure analysis supply chain architecture and how that value can be achieved. In this section, we will identify how to determine the value required from the failure analysis supply chain, describe a desired state and describe a case study to identify the gaps between current and future states of the supply chain.[12]

3.1. Define a vision for the failure analysis supply chain

Companies have long understood the need for mission and vision statements to align the employees and stakeholders around the goals of the company and ensure that everyone focuses their activities on achieving the vision. Similarly, the company can define a vision for individual organizations and for cross-functional business processes like failure analysis supply chains. A vision statement that defines the company's commitment to high customer satisfaction and a positive customer experience aligns the various, disparate stakeholders within the failure analysis supply chain around a common goal of ensuring that customers will remain at the forefront of each groups' activities. By bringing together various stakeholder groups in defining the vision, the company can ensure that each group agrees with the vision and is committed to executing to achieve that vision.

3.2. Identify customer needs for the failure analysis supply chain

Customers who purchase products from companies desire a problem-free operational experience from the product, and good customer service in the event that they encounter issues. In addition,

[12] The approach presented here has been adapted from ESD.38 Enterprise Architecting class taught at MIT in 2006.

business customers who purchase higher complexity products from companies like Dell or IBM for mission critical operations are concerned about the product lifetime, repair and serviceability of products, likelihood of failure and root cause identification and resolution time in the event of a failure. Such customers will expect a higher level of service from the high-tech firm. On the other hand, companies that produce low end products may choose to provide a lower-level of service than companies that cater to mission-critical applications. High-tech companies, therefore, need to look at their individual product portfolios, customer demographics, customers' applications and their firm's business strategy when identifying the needs of their customers and the level of service they will provide with their failure analysis supply chain.

Individual companies can identify their customer needs through a variety of channels and mechanisms. As suggested in Chapter 2, it will be necessary for channel members to share their findings with other members of the cross-functional failure analysis supply chain. For example, sales account managers can provide feedback from their customer interactions during the sales and order fulfillment process. Technical support centers have a direct channel to customers with problems and can identify what would make customers happy. Repair and field service organizations can understand customer issues and identify customer needs through direct interaction. Formal customer surveys can help solicit feedback from important customers and ensure that their needs are addressed. Direct observation of customers and process mapping can also provide valuable information on customer needs. Additionally, other forms of "Voice of Customer" activities like focus groups, interviews, simulations etc. can be utilized to obtain customer needs for the company's failure analysis system. Cisco, for example, identified that their current failure analysis system was not meeting the needs of their customers and started a cross-functional re-architecting project to improve the failure analysis supply chain. Many of their customers, including large telephone service providers, cable operators, enterprise banking and internet retailing customers, operate revenue-impacting activities on Cisco's networking products. Through Voice of Customer activities, companies like Cisco might find that their customers value short turnaround time (i.e., quicker response), ongoing communication, root cause identification, and implementations of fixes to address the root cause (in current and future products).

3.3. Identify the value needed by the enterprise

There are a number of definitions and interpretations of “enterprise”. In this thesis, we will use the Nightingale and Rhodes description of enterprises as “complex, highly integrated systems comprised of processes, organizations, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries.”[13] In this context, an enterprise is made up of a number of stakeholders, including customers, end-consumers, employees, suppliers, shareholders, unions, partners, corporation, and society as shown in Figure 5 below. Nightingale and Rhodes suggest that it is important to understand and balance the value needed by and delivered to all stakeholders while architecting or re-architecting an enterprise as an engineering system.[14] Since the customer can be treated as a unifying stakeholder that brings together all the other stakeholders through revenue generation, we chose to separate the value needed by the customer in the previous section from the needs of the other stakeholders. Most high-tech enterprises include a number of the stakeholders described here – suppliers, employees, shareholders, partners etc. Furthermore, each stakeholder group may be divided into separate functional groups such as finance employees, marketing employees, development employees, manufacturing employees etc. The company should try to identify the value needed by as many stakeholders as possible. This can be achieved through a number of mechanisms including formal and informal interviews, identification of processes through process mapping, focus groups, employee surveys and other stakeholder surveys (e.g., supplier management surveys).

[13] Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.
[14] Nightingale and Rhodes describe enterprise architecting as providing the approach for analyzing and understanding the ‘as is’ enterprise, and allowing the various alternative changes and interventions to be analyzed.

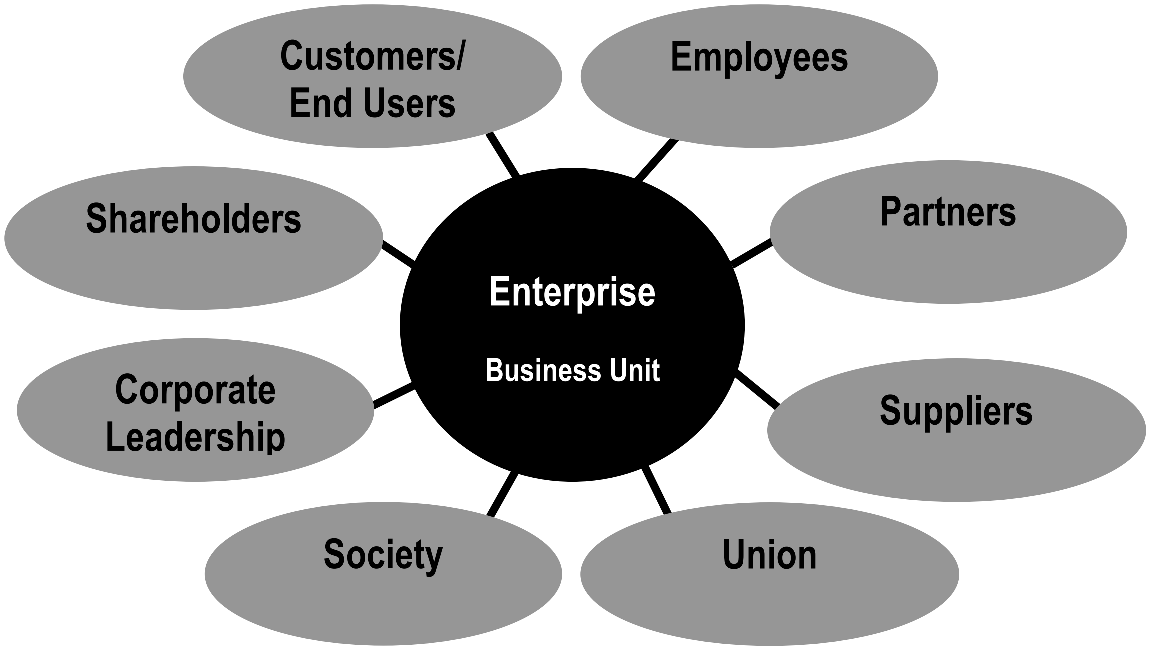

Figure 5: An enterprise consists of various stakeholders interacting with each other

In the context of the architecture of a failure analysis supply chain, the value needed by different stakeholders and functional groups within the enterprise may be different. For example, shareholders value the return on their investment (or equity) and are concerned about operational and financial performance. The finance group might be concerned about reducing the overall cost of the supply chain operations and taxes paid to transport or manufacture goods. Development may desire feedback on failures and root causes from the supply chain in order to improve the next generation of products. Manufacturing may worry about simplifying the handoffs and getting feedback on potential manufacturing defects that were uncovered by the FA supply chain. Supplier management may be concerned about ensuring consistency of processes and requirements across various suppliers. Logistics managers may want tracking and visibility to the products during transit. Technical support and customer service stakeholders would probably be concerned about simplification of case logging, tracking and reporting processes and relevance of information that is available to satisfy customers. From a broader perspective, the unions may be concerned about the working conditions and ensuring labor tasks and processes are aligned with skill sets, and the society may value minimal environmental impact resulting from the failure analysis supply chain. By identifying the value that is needed by the overall enterprise, the company can envision the specific features and behaviors that the future failure analysis supply chain should have. Furthermore, by understanding where their current processes and architecture fail to meet the needs of the customers and other stakeholders in the enterprise, companies can determine where the most effort will be needed during the re-architecting process.

3.4. Determine the gap between current and future states

Once the company has identified the value that is needed by the various enterprise stakeholders in the future state and understands the problems in the current state of the failure analysis supply chain, the gaps between the current and future states can be elaborated upon. Chapter 2 described some of the major problems in failure analysis supply chains and returns processes. Earlier in this section, we identified potential value that stakeholders in the future state might need. Gap analysis would involve determining where the processes and strategies from the current state would need to change in order to meet the needs of the future state. For example, current failure analysis supply chains suffer from high costs (partly due to manual processing). Failure analysis stakeholders desire lower cost (e.g., finance) and simplified processes (e.g., employees/unions). Thus the gaps between current state and future state can be identified as they relate to the cost drivers of the failure analysis supply chains. While specific strategies and implementation changes to address these gaps are not the primary focus of this section, a high-tech company could, for example, look at automation of information systems as a means to reduce operational costs (from use of manual labor) and to simplify the processes (by using less manual processing). During its re-architecting effort, Cisco identified gaps in 11 major areas around end-to-end process and operations in specific areas. From these major areas, the company determined gaps in 45 detailed areas between the current state and desired future state of their failure analysis supply chain. Several working teams were responsible for coming up with ideas to address these gaps in conjunction with the appropriate, impacted stakeholders. These ideas would be utilized to develop implementation plans to re-engineer specific aspects of the failure analysis supply chain.

3.5. Envisioning the future Failure Analysis Supply Chain at Cisco

Using the Cisco[15] context as an example, this section will describe how the future state of the failure analysis supply chain and the gaps between the current and future states can be identified.

3.5.1. Returns process improvement history at Cisco

Over several years, Cisco understood that their current failure analysis supply chain did not meet the needs of their customers and other enterprise stakeholders and started a number of initiatives to improve the overall system. Some of these initiatives were started by the customer service and technical support teams, others were started by the manufacturing group and still others were started by the reverse logistics group. Some initiatives were driven by executive sponsors working with external consultants, while others were driven by wholly internal groups. While the intentions of each of these project teams were to improve the overall system, lack of buy-in and support, limited funding, and challenges in implementation resulted in most initiatives being redirected or terminated prior to completion. In some cases knowledge and lessons learned were documented and shared, while in other cases the knowledge was implicitly held by employees who had been involved in the specific initiatives.

3.5.2. Closed Loop Corrective Action to achieve excellence in quality

To address the challenges that Cisco has observed in their returns process and failure analysis system, Cisco began a new thrust called "Closed Loop Corrective Action" within their enterprise-wide Manufacturing Excellence (MX) initiative. The Manufacturing Excellence initiative at Cisco "sets aspirational goals to drive world class performance in manufacturing as well as the supply chain in quality, delivery, cost and other areas."[16] The MX initiative was started to determine where the manufacturing strategies, supply chains and processes were able to support Cisco's new geographies and technology areas, and to make "aspirational" rather than incremental improvements to Cisco's manufacturing and supply chain. Angel Mendez, Senior Vice President of Manufacturing at Cisco, in a September 2006 interview with *Purchasing*

---

[15] The Appendix provides background information on Cisco Systems, Inc.
[16] Angel Mendez, Sr. VP of Manufacturing quoted in: Carbone, J. "Supply Chain Manager of the Year: Steve Darendinger Champion of Change." Purchasing Magazine. Sep 21, 2006.

Magazine identified the company's goal "to be world-class in everything including new product introduction, cost, quality and delivery." The company identified areas where it was strong (like procurement and sourcing) and other areas that needed improvement (new product introduction and forecasting). The company recognized that "quality was strong, but there were opportunities for improvement." The Closed Loop Corrective Action (CLCA) thrust was Cisco's initiative for improving end-to-end product quality including the failure analysis supply chain and customer communications relating to quality. Recognizing that some of the previous projects had failed due to lack of buy-in and employee engagement, CLCA was started as a cross-functional initiative with executive sponsorship from all the major functional stakeholder groups that touched product quality, failure analysis and related manufacturing and supply chain processes. Within the CLCA initiative, a major project was undertaken to specifically look at Cisco's Global Failure Analysis system and identify gaps and areas for operational excellence. The vision of the Failure Analysis (FA) initiative was envisioned by the cross-functional team as "providing a best-in-class customer experience, by making available consistent and accurate root cause hardware failure data, and thereby promoting reliability improvements throughout the product lifecycle"[17].

3.5.3. Identifying the value needed by failure analysis stakeholders

Cisco was determined to identify the problems and challenges within the current failure analysis system and started using focus groups with key customers to identify their needs. These focus groups also identified specific frustrations and challenges that customers encountered when interacting with the Cisco failure analysis system. Many of the problems described in Chapter 2 also plagued Cisco's failure analysis system. High turnaround time and inadequate diagnosis of the root cause were important gaps between the desired state and current capabilities offered by Cisco's failure analysis supply chain. In addition to identifying customer needs, the project team tried to identify the needs of the remaining enterprise stakeholders.[18] The broader list of needs was then detailed into requirements for the future failure analysis system, with specific high-level goals to reduce turnaround time, improve diagnosis and develop consistency across

[17] Vision was documented by Cisco's Global Failure Analysis initiative.
[18] Enterprise stakeholders for this project were limited to "internal groups" under Cisco control and did not directly include the outsourced partners, suppliers, society or any unions.

processes involved. Sub-teams within the FA initiative then identified gaps between the current state and the desired future state of the global failure analysis system. This was achieved through development of as-is (current state) and to-be (future state) process maps, review of operational metrics that were used, investigation of capabilities of information systems and informal discussions with members of the various functional groups.[19] In addition, the team determined that further efforts would be needed to design the future state of the failure analysis supply chain and select sites, processes and supporting infrastructure among the alternatives available. In particular, the future failure analysis supply chain needed to be "cost effective, robust, and meeting the technical and business requirements of the Global Failure Analysis system". The author's internship project utilized an understanding of the as-is state of the Cisco failure analysis system to investigate and propose a best practices framework that could be applied to the Global Failure Analysis system (described in Chapter 4). The project outcome also included development of a decision model for selection of a failure analysis supply chain and recommendation of the best alternative (described in Chapter 5).

3.5.4. Identifying gaps in Cisco's failure analysis system

During this internship, stakeholders of the FA process were interviewed to determine their perception of the as-is Global FA system at Cisco. This included the project manager, members of the manufacturing quality team, reverse logistics team, engineering failure analysis team, supply chain strategy team, the customer service and repair teams and the Six Sigma Master Black Belt guiding the FA process redesign effort. In addition to these interviews, Voice of Customer input from customers, as-is process maps, conceptual design for the to-be FA process, and existing policy documents relating the FA system were also reviewed to understand the major process gaps. Much of this information was gathered from the stakeholders previously interviewed and from internal Cisco documents.

Four major pain points relating to the historical FA system emerged from the interviews and process review:

[19] Due to confidentiality reasons, detailed requirements and gap analysis are not presented in this thesis.

1. ***Customers perceive a very high FA turnaround time (TAT)*** – It takes more than a month on average from the time that the customer calls to open an FA case to the time that the return is received at the FA site and several months on average for customers to receive the failure analysis report.

2. ***Outsourced sites differ in the skills or capabilities necessary to support FA*** – Cisco's FA system has multiple outsourced geographic locations (contract FA sites, other FA sites, repair depots, consolidation centers etc.) that execute on the FA process. FA is primarily conducted at contract sites specializing in Repair, often on a separate FA line. However, the contract FA sites have differing levels of capabilities and root cause analysis skills in various locations. This lack of FA specialization results in "Can Not Duplicate" FA case reports from the FA sites and significant backlog at the engineering FA and business unit specific labs where 2nd level FA (i.e., root cause analysis) is conducted by failure analysis engineers for difficult to diagnose cases. In general, site capabilities and constrained resources mean lack of closed loop feedback for design and process improvement.

3. ***Information infrastructure and product visibility in the FA system is inadequate*** – The current FA process requires accessing multiple systems to process an FA case due to lack of integration with the reverse logistics system. Furthermore, part routing is based on manual input into the FA system. Lack of integration makes sorting of high-priority FA cases at the dock challenging, and prevents customers from having visibility to the returned products and status of their FA cases. The manufacturing quality metrics team determined that a significant proportion of the FA cases were closed due to non-receipt of parts and several FA cases were cancelled after receipt.

4. ***The FA system needs to be cost effective*** – There was little understanding within Cisco about the total cost for failure analysis and the downstream effect on overall product and service revenues. The repair team had estimates on new product buy avoidance if excess FA inventory could be redeployed. The reverse logistics team was able to estimate the FA-related processing and handling costs. The engineering FA team understood the standard cost for an FA case that was negotiated with contract manufacturers. However, the effect of taxes, duties, global routing

and related supply chain costs was usually not considered in the FA system. Managing total FA costs would allow Cisco to appropriately scale operations and allocate efforts more effectively to meet customer expectations around quality.

4. HOLISTICALLY ARCHITECTING THE FAILURE ANALYSIS SUPPLY CHAIN

4.1. Traditional approaches are inadequate for architecting the complex failure analysis supply chain

Traditional enterprise architecting has been studied by numerous academics in the management and social sciences fields for a number of years. However, most of this work has been carried out with a singular focus on information technology systems (i.e., traditional "enterprise architecting"), process views,[20] and architecting organizations.[21] Companies that have tried to architect or re-architect their systems and organizations, tended to consider the process, organizational structure, culture, information technology etc. in isolation, and make improvements to each separately. For example, within the failure analysis supply chain, they might focus on the reverse logistics processes and identify ways to optimize these processes. While the optimization (or redesign) of the process might identify areas for improvement of the supporting information systems infrastructure, changes to that infrastructure would be handled as a separately funded project. In the meanwhile, workarounds are implemented to operate using the new process and the old information systems. In other cases, companies might choose to re-organize their manufacturing groups to improve alignment with business units, while leaving the resulting process changes to a separate initiative.

Unfortunately, most of these perspectives used by companies today are inadequate to architect complex enterprises like a Global Failure Analysis system consisting of multiple stakeholders, including outsourced partners interacting with each other. These interactions among stakeholders create different dynamics under different strategies, policies, and structures which cannot be considered in isolation. Recent enterprise architecting research suggests that a broader perspective is necessary to consider the interactions between the multiple dimensions of the

---

[20] Pall, G. A. The Process-Centered Enterprise: The Power of Commitments. New York: St. Lucie Press, 1999.
[21] Rechtin, E. Systems Architecting of Organizations. CRC Press, 2000. and
Bernus, P., L. Nemes, and G. Schmidt. Handbook on Enterprise Architecture. Springer, 2003.

enterprise.[22] A holistic approach can be adopted when architecting and designing a failure analysis enterprise that considers the interdependence of the various parts and the importance of the entire networked enterprise. Collaboration between stakeholders and their involvement during architecting is an integral part of this holistic approach. A high level approach to architecting the failure analysis supply chain involves:

i) understanding the current failure analysis supply chain
ii) identifying the vision for the future failure analysis supply chain
iii) investigating the issues in the current system and the gaps between the current and desired state
iv) identifying possible solutions or approaches to closing the gaps
v) selecting among alternative approaches and recommending an approach

The holistic approach involves utilizing these steps in conjunction with an integrated framework of architectural views.[23] Before describing the recommended architectural framework, we identify some of the other approaches found in literature for architecting (or designing) reverse supply chains.

4.2. Other approaches to Reverse Supply Chain architecture and design

Recently, supply chain related academic literature has started to describe the problems and issues associated with reverse supply chains (and closed-loop supply chains consisting of both forward and reverse elements). Much of the literature is around understanding the strategic and operational problems faced in the reverse supply chain. Guide, Harrison, and Van Wassenhove wrote an overview paper in 2003 describing the challenges of closed-loop supply chains.[24] In this paper they describe the fundamental problem that industry and academics "rarely consider the reverse supply chain as a business process" and companies often don't encourage their design engineers to design products for disassembly and remanufacturing. This paper proposes that cross-functional collaboration is necessary to prevent consideration of various activities within

[22] Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.
[23] Nightingale, D., and D. Rhodes. Lecture Notes from MIT Graduate Class ESD.38J Enterprise Architecting. 2006. Nightingale and Rhodes describe an architectural view as a perspective on a system (enterprise) describing a related set of attributes.
[24] Guide, V. D. R., T. P. Harrison, and L. N. van Wassenhove. "The Challenge of Closed-Loop Supply Chains." Interfaces 33.6 (2003): 3-6.

reverse supply chains in isolation. Furthermore, they argue that while most industry and academic approaches consider the operational or tactical issues within reverse supply chains, the strategic question of profitability, which is often ignored, is more important and must be the focus for reverse supply chain improvement. These authors suggest that academia and industry should consider the interdependence of the reverse supply chain elements together with business strategy to devise models and frameworks based on integrated business-process perspectives.

In another paper,[25] Spengler and Schroter[26] describe the problems in developing tools for information and spare-parts systems in a closed loop supply chain for Agfa-Gavaert AG and Electrocycling GmbH. Their system dynamics approach considers scenarios for production and recovery systems to understand the cost-effectiveness of recovery of parts from the system. This approach considers the information requirements within specific supply chains. Fleishman, van Nunen, and Grave utilize another information model for inventory control along with simulation to demonstrate how effective information management is important for utilizing spare parts from product returns at IBM.[27] Toktay, van der Laan, and de Brito discuss the role of return flow information and forecasting in managing product returns in order to maximize the value from the reverse supply chain.[28] Van Nunen and Zuidwijk describe the importance of information and communication technology in closed-loop supply chains to help companies realize new business opportunities.[29]

A few academics also apply variants of traditional forward supply chain approaches to the reverse supply chain. Kekre, Rao, Swaminathan, and Zhang[30] used asset utilization techniques, optimization and simulation to redesign the remanufacturing line at Visteon, an auto parts

---

[25] There was a special section in Interfaces, Vol. 33, No. 6. (2003) on closed-loop supply chains.
[26] Spengler, T., and M. Schröter. "Strategic Management of Spare Parts in Closed-Loop Supply Chains-A System Dynamics Approach." Interfaces 33.6 (2003).
[27] Fleischmann, M., J. A. E. E. van Nunen, and B. Graeve. "Integrating Closed-Loop Supply Chains and Spare-Parts Management at IBM." Interfaces 33.6 (2003): 44-56.
[28] Toktay, L., van der Laan, E., and M. de Brito. Managing Product Returns: The Role of Forecasting. Erasmus Research Institute of Management, 2003.
[29] van Nunen, J., and R. A. Zuidwijk. "E-Enabled Closed-Loop Supply Chains." California Management Review 46.2 (2004): 40-54.
[30] Kekre, S., et al. "Reconfiguring a Remanufacturing Line at Visteon, Mexico." Interfaces 33.6 (2003).

manufacturer, to improve their throughput. Schultmann, Engels, and Rentz[31] applied a combination of optimization techniques for network planning and flowsheet process models to reverse supply chains for batteries in Germany.

Yadav, Miller, Schmidt, and Drake[32] describe another approach to reverse supply chain design using contracts with shared incentives at McGriff Treading Inc., resulting in lower cost of tires for trucking-fleet vehicles. This approach considers the cooperation between tire retreading (supplier) and the fleet operator (the company) and shows the importance of setting shared savings goals and measuring performance against those goals.

Some approaches to reverse supply chain design focus on the structure of the supply chain for remanufacturing and product recovery,[33] and network design for reverse logistics using analytics.[34] Other approaches consider the value of information within the reverse supply chain,[35] while others consider the strategic importance of time in the reverse logistics process.[36] Pochampally and Gupta incorporate economic analysis approaches to a mathematical model for designing an efficient reverse supply chain.[37] A few research initiatives are taking more integrated approaches to designing reverse supply chains. For example, Ahmed describes an integrated approach to reverse supply chain planning (one element of the system), that considers the business model, processes and enabling technologies as interconnected elements that must operate together for efficient supply chain management.[38] Tan, Yu and Arun consider the

---

[31] Schultmann, F., B. Engels, and O. Rentz. "Closed-Loop Supply Chains for Spent Batteries." Interfaces 33.6 (2003).
[32] Yadav, P., et al. "McGriff Treading Company Implements Service Contracts with Shared Savings." Interfaces 33.6 (2003).
[33] White, C. D., et al. "Product Recovery with some Byte: An Overview of Management Challenges and Environmental Consequences in Reverse Manufacturing for the Computer Industry." Journal of Cleaner Production 11.4 (2003): 445-58.
[34] Fleischmann, M. Reverse Logistics Network Structures and Design. Vol. Reference No. ERS-2001-52-LIS. Erasmus Research Institute of Management, 2001.
[35] Ketzenberg, M., van der Laan, E., and R. Teunter. The Value of Information in Reverse Logistics. Erasmus Research Institute of Management, 2004.
[36] Souza, G. C., et al. Time Value of Commercial Product Returns. 2003.
[37] Pochampally, K., and S. Gupta. "Efficient Design and Effective Marketing of a Reverse Supply Chain: A Fuzzy Logic Approach." IEEE International Symposium on Electronics and the Environment. 2004.
[38] Ahmed, A. "A Holistic Approach to Reverse Supply Chain Planning for Remanufacturing." IEEE Proceedings of EcoDesign2003. Dec 2003.

combination of returns policies, cost metrics and integration of information systems in the improvement of reverse logistics operations for a spare-parts supplier in Asia.[39]

4.3. An Enterprise Architecting framework for Reverse Supply Chain

Nightingale and Rhodes describe architectural frameworks as "standards for the architecture of the product….." that "….define the products an architect must deliver and how those products must be constructed – without constraining the product content". They suggest that "architectural views" i.e., "perspectives on the enterprise describing a related set of attributes" can be used to simplify the overall architecture and describe different parts of the whole architecture. By using views, the architect can isolate certain parts for focus (e.g., the strategy view to describe the business strategy followed by the enterprise) and reduce the complexity of the whole enterprise.[40] Some of their work in the Lean Aerospace Initiative at MIT and development of a graduate level course on "Enterprise Architecting" aims to consolidate different perspectives proposed by other researchers into an "Enterprise Architecting Framework" that can be used to architect or re-architect an enterprise. This broader framework is adapted for the reverse supply chain design context and presented as a specific enterprise architecting framework for "Reverse Supply Chain" made up of 6 different views as shown in Figure 6. Each view considers a different aspect of the enterprise architecture and allows high-tech companies to isolate and focus on a single view to identify value delivery to enterprise stakeholders in the as-is state and best practices that can be adopted to improve the value delivery in the to-be enterprise.

4.3.1. Governance

The Governance view considers the enterprise's business model, business strategy, internal and external policies that impact the enterprise, alignment among policies, strategy and organization, management of the business, continuous improvement and design principles applied within the business.

---

[39] Tan, A., W. Yu, and K. Arun. "Improving the Performance of a Computer Company in Supporting its Reverse Logistics Operations in the Asia-Pacific Region." International Journal of Physical Distribution and Logistics Management 33.1 (2003).
[40] Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.

4.3.2. Process

The Process view considers key processes and activities within the reverse supply chain. This includes processes that are directly involved in the gatekeeping of products and cases, acquisition of the products back from customers, reverse logistics operations, disposition of the products returned to the company and recovery of value from the products. It also includes management of the end-to-end process and customer experience and processes for monitoring the operations.

Figure 6: Enterprise Architectural Views for Reverse Supply Chain

4.3.3. Reverse Supply Chain Design

The Reverse Supply Chain Design view considers the enterprise from the perspective of designing the reverse supply chain structure. This might include network design of the supply chain (e.g., location of facilities), optimization of the supply chain, reverse logistics design, inventory management, financing activities and outsourcing related decision making. This view recognizes that the "configuration of [an operating] network has major implications for its cost structure, asset utilization, delivery lead times, stability, responsiveness, flexibility, customer services and its company's financial performance" and "different network structures have different strengths and weaknesses." [41]

4.3.4. Organization

The Organization view is used to understand the ownership and structure of the organization within the enterprise, alignment across the organization, and cultural elements involved with managing a cross-functional organization. For example, this view can be considered to understand the impact of functional silos on the overall enterprise.

4.3.5. Enabling Technology

Enabling Technology includes the hardware, software, communications, and knowledge management systems that support the enterprise. In the context of a reverse supply chain, this enabling technology view considers process automation, visibility, technology systems like RFID, warehouse management etc., and knowledge management processes and systems. For example, historical returns information and product knowledge captured during failure analysis processing can be used to facilitate business process improvement and used within decision support tools.

4.3.6. Performance Management

The Performance Management view considers the measurement and benchmarking processes and systems required to manage the business. It also includes key performance indicators (KPIs) that are important to measure within the reverse supply chain enterprise. This view allows the enterprise to measure the success of any new or redesigned process. For example, process improvement can be measured using a combination of benchmarking against industry peers, against previous incarnations of the process, and through measurement of progress on key performance indicators (KPIs). Product quality and supply chain KPIs range from financial

[41] Hayes, R., et al. Operations, Strategy, and Technology: Pursuing the Competitive Edge. Hoboken, NJ: Wiley, 2005.

metrics like ROI and service-related revenues, to qualitative metrics like marketing benefits from lower return rates, to process metrics like cycle time, cost, asset efficiency and customer service scores.

4.4. Reverse (Failure Analysis) Supply Chain Best Practices Framework

The Reverse Supply Chain architectural framework can be utilized to evaluate the current state of the enterprise, understand best practices within the enterprise and across multiple industries and apply such best practices to improving the supply chain enterprise. In this research, an extensive literature review was conducted to identify practices used and recommended within closed loop supply chains, repair and failure analysis processes, supply chain and reverse logistics systems.[42] While few standards exist around failure analysis best practices, the Supply Chain Council and Reverse Logistics Executive Council provide knowledge-databases for related white papers and articles. Operations management related journals and analysts like Aberdeen research, Gartner and Forrester provide additional information on best practices that could be adopted within the failure analysis supply chain. Some papers describe the approach that companies like IBM have taken to manage spare parts while others describe how technology has been applied to various industries including retail, high technology and industrial goods to improve their returns processing. Using this literature as a foundation, the best practices were categorized within the broad Reverse Supply Chain architectural framework described earlier to create the "Reverse Supply Chain Best Practices Framework" which is described in the Appendix in section 9.3. This best practices framework can be applied to the business needs and customer "pain points" gathered during the "understand the as-is" phase of the failure analysis re-architecting effort as shown in Figure 7.

[42] Sources for this literature review are listed in Appendix 9.3 along with the detailed best practices.

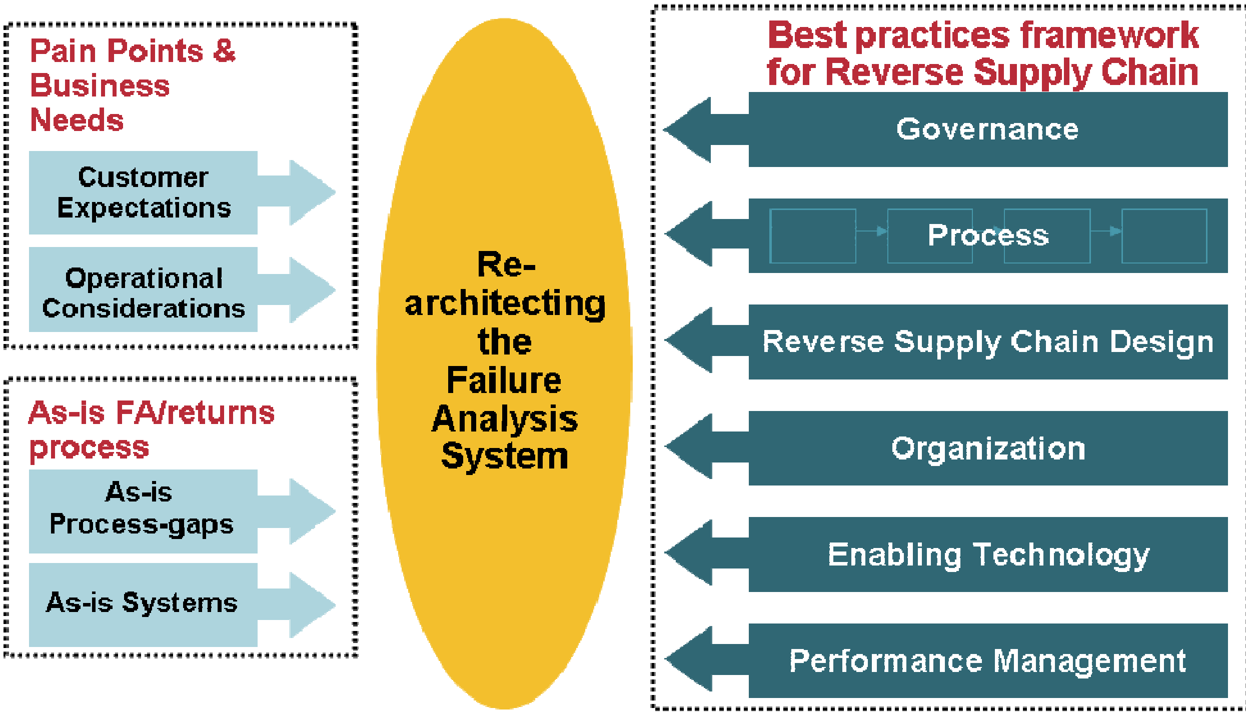

Figure 7: Reverse Supply Chain Best Practices Framework can help address the pain points and business needs during the re-architecting process

In addition, the Reverse Supply Chain Best Practices Framework (described in detail in the Appendix in Section 9.3) can also be used as a foundation for capability diagnostics, competitive benchmarking, and process improvement and enterprise re-architecting efforts similar to the Supply Chain Operations Reference (SCOR) model that is utilized across many high-tech firms to Plan, Source, Make, Deliver and Return products[43] and services. An example of the capability diagnostic tool using the best practices framework is shown in the Appendix in Section 9.4. In the next chapter, the reverse supply chain best practices are utilized in conjunction with customer pain points, business needs and process gaps to select a new reverse supply chain design among a set of alternative designs.

[43] The SCOR model (with Plan, Source, Make, Deliver, Return as processes) is a process reference model that has been developed and endorsed by the Supply-Chain Council as the cross-industry diagnostic tool for supply-chain management. "Supply Chain Operations Reference (SCOR 8.0) Model." Supply-Chain Council. <http://www.supply-chain.org>.

5. SELECTING THE OPTIMAL SUPPLY CHAIN DESIGN USING A DECISION MODEL

5.1. Decision making is an integral activity within enterprises

In every enterprise, decisions are made on a continual basis at all levels – strategic, operational and tactical. Decisions are made about the direction of the firm, the suppliers to form relations with, which customer orders to fulfill, etc. While some decisions are top-down (i.e., handed down by the leader to be implemented by the organization), increasingly decisions are made at lower levels in the organization. The leadership style within the organization often determines where in the enterprise the decisions might be made. In either situation, decisions may involve debate and conflict, in which multiple decision makers discuss the pros and cons of the decision or consensus in which every member of the decision-making (or decision-influencing) group agrees to implement the decision. Decision making could occur using both debate (of the issues involved) and consensus (where every group member agrees to implement the decision whether they agree completely with it or not). While many high-tech firms often use debate to understand the pros and cons of issues involved in the decision, consensus is not always emphasized. Rather, the outcome of the decision (i.e., whether it is the "right decision") plays an increasingly important role. What some organizations fail to recognize is that consensus can play an important role in building commitment from the groups involved and in providing a strong, shared understanding of the rationale for the decision. Commitment from members in across-functional decision making team is critically important in firms that need different organizations or functions to coordinate with each other and ensure that the recommended action will be implemented, especially by those who may have disliked the action. The shared understanding of rationale will help with implementation, by building momentum to overcome any obstacles that might arise.[44]

[44] This has been partly adapted from: Roberto, M. "Why Making the Decisions the Right Way is More Important than Making the Right Decisions." Ivey Business Journal. 2005. See this article more information on how decisions are made.

5.2. Modeling the Failure Analysis Supply Chain Decision

Failure analysis supply chain decisions that involve multiple stakeholder groups for input, discussion and action are not much different from those described above. Such decisions should involve debate by the groups that are impacted or will need to contribute in the new enterprise architecture, and require consensus to ensure success of the implementation of the system and process. Decisions made within organizations may be based on deeply ingrained assumptions about customers, organizations, processes and approaches to certain activities giving rise to "conventional wisdom" that may be followed by the firm or entire industries.[45] In many firms, employees and managers dislike "processes" that they believe hinder, rather than aid them, and rely on their experience and the conventional wisdom about "the way we do things" in that organization. Ad-hoc decision making becomes the oft employed approach to reaching the desired "decision outcome".

5.2.1. Why Model

Due to the number and nature of the issues and problems that need to be considered in deciding among alternative supply chain architectures and designs, an ad-hoc decision making approach based on gut feel may not produce the desired outcome. A data-driven model can help facilitate discussion, debate and consensus building during the decision making process. A model allows involved stakeholders to get their assumptions documented "on paper", so that ambiguity about the assumptions is avoided during discussions. The model can be used to consider several issues (or decision making variables) together and in isolation (as needed). Modeling allows stakeholder groups to share their inputs about assumptions, variables, priorities and recommendations with all other groups in a more objective fashion than just claiming that "something is better than something else". In addition, the modeling assumptions and outcome can be documented for future reference or modifications.

---

[45] Roberto, M. "Why Making the Decisions the Right Way is More Important than Making the Right Decisions." Ivey Business Journal. 2005.

5.2.2. Decision Model for Failure Analysis Supply Chain

In this research, a data-driven decision model was used to make recommendations about the failure analysis supply chain design that could address customer needs and process gaps within the current FA system. Decision support tools like this decision model enable objective, data-driven decision making in cross-functional projects with large numbers of stakeholders. The Cisco decision model considered which sites should be used for failure analysis (i.e., the failure analysis supply chain network) to support the new Global Failure Analysis system. The model was structured in the form of a "concept selection matrix" with various design alternatives rated against weighted decision criteria. The overall rating along with a risk-assessment was used to recommend the best alternative among the various designs considered. The Microsoft Excel based model was developed using the high-level process outlined in Figure 8 below. Details of the model are described in the Appendix in section 9.5.

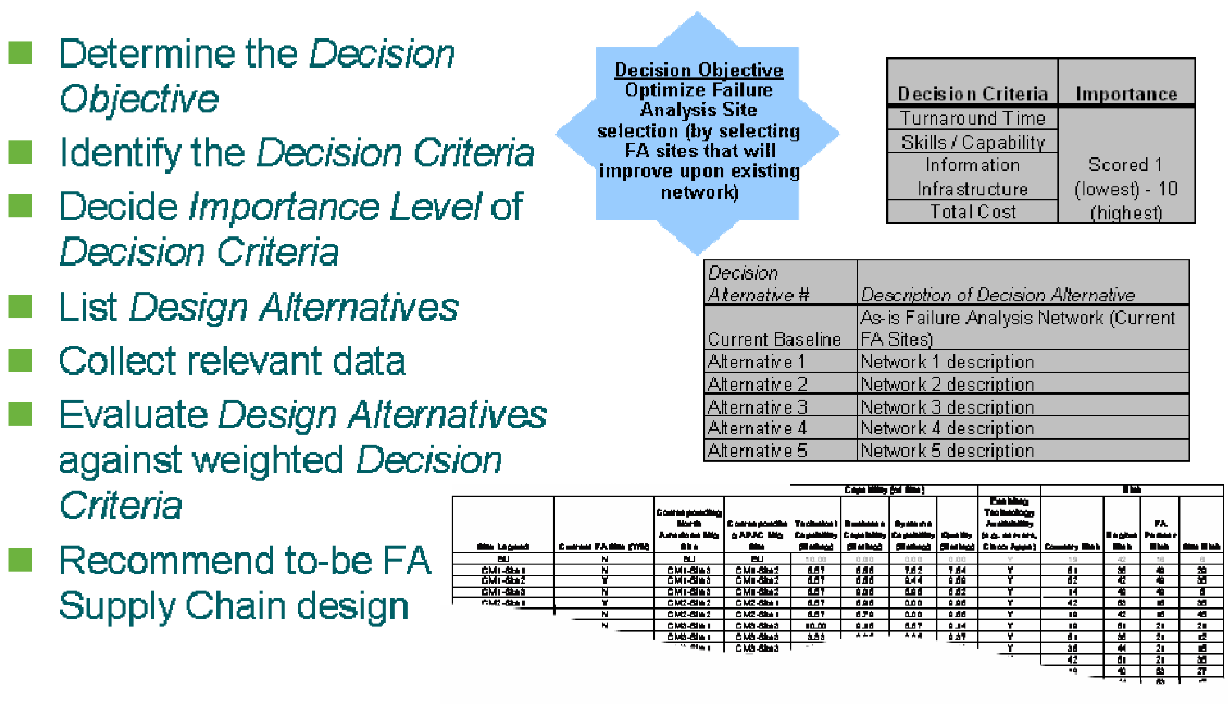

Figure 8: Process for developing the Decision Model for Failure Analysis Supply Chain

The decision model used input from various stakeholders that were impacted by and who impacted the failure analysis system and related processes. This modeling approach emphasizes the importance of capturing input and data from a cross-functional group of stakeholders who may be responsible or accountable for the ongoing systems, involved in the new processes, or impacted by the new system. Each stakeholder group is expected to help the analyzing team members gather relevant data and information that is under their control or influence and needed for the decision. Input from the stakeholder groups is critical to reaching a sustainable decision with relevant buy-in for implementation. At a minimum, the following stakeholder(s) should be represented in the core team for Failure Analysis related decision making:

1. *Engineering Failure Analysis or Engineering Quality team*
2. *Manufacturing Failure Analysis or Manufacturing Quality team*
3. *Corporate Quality team (if different from above)*
4. *Service or Technical Support team*
5. *Returns related Logistics team*
6. *Supply Chain or Manufacturing Strategy team*
7. *Outsourced site managers*

Other stakeholder groups who can provide input to the decision should be included on an as-needed basis (e.g., Supply Chain Risk, Supplier Management, IT, Finance, Legal etc.)

This decision model also incorporated the failure analysis supply chain best practices from the Reverse Supply Chain Best Practices Framework in the decision framework. The pain points and process gaps were identified as the basis for the decision criteria against which alternative supply chain designs would be evaluated. These decision criteria consisted of several sub-criteria drawn from best practices review and internal processes relating to reverse logistics, trade, failure analysis and customer returns. Alternative supply chain designs included using the as-is network (current baseline), using repair sites, using manufacturing sites, using new product introduction sites, etc. within the global or within regionally focused networks (e.g., conducting failure analysis at contracted sites in Asia versus Europe, Latin America or North America).

While this decision model was developed for a specific decision regarding Failure Analysis site selection, it can also be applied to other supply chain or site selection decisions, such as determining where return depots, logistics centers, manufacturing sites, etc. should be located. In such cases, the methodology shown in the Appendix would be similar while the decision criteria, importance ratings and design alternatives might be different.

5.2.3. Recommendations from the decision model

The recommendation from the decision model was to align failure analysis sites with the Alternative 1 design based on its highest overall rating. This alternative consisted of a supply network of existing sites managed by outsourced Cisco partners[46]. Due to the existing Cisco relationships, processes and logistics supporting these sites, Alternative 1 provided the best overall value to Cisco and its customers based on the decision criteria described in more detail in the Appendix in section 9.5. This recommendation had some risk associated with it, not all of which could be immediately be mitigated. However, given that all the alternatives were risky (the risk rating was primarily due to lack of data for some product families and sites), it was believed that additional data gathering would demonstrate that the risk associated with Alternative 1 could be mitigated. Further investigation was recommended to determine whether the overall benefits from investing in a transition from the current failure analysis network to the recommended Alternative 1 network would be net positive. In particular, additional information relating to setup cost, ongoing negotiations with the contract manufacturing and failure analysis partners, and ongoing risk-assessment for some sites would help clarify if the decision outcome could be implemented.

5.2.4. Frame of reference matters during modeling

During the decision model development effort, it is important for the analyst and the decision making team to recognize the "frame of reference" or perspective that was used to develop the model. In general, each member of the decision making team has a "frame of reference" from which he or she approaches the decision. For example, an engineering team member purely looking at a failure analysis system from the technical perspective may value technical capabilities of the staff and outsourced partner more than any other decision criteria. Similarly, a manufacturing or supply chain team member may consider cost to be the most important criteria

[46] Some of these sites may conduct failure analysis on some Cisco products, while others do not.

for decision making. A quality team member may focus on the quality metrics as being most important when improving the failure analysis supply chain, while an IT person may believe that systems connectivity and features play the most important role in ensuring smooth flows in the new failure analysis supply chain. While none of the team members can be faulted for their individual perspectives, a stronger emphasis on one decision criteria versus another could result in a different overall rating for each of the decision alternatives. A purely technical-capability frame of reference would result in the most highly capable site being selected for failure analysis which may be located in a high-cost region. In such cases, although the technical team desires implementation of the new design based on capability, the supply chain team may be reluctant to execute on an extremely high-cost proposal. On the other hand, a purely labor cost-focused frame of reference would result in the cheapest labor rate site being selected at the expense of total cost (including shipping, customs, trade, etc.) and quality of diagnosis. This may result in cost savings in the short term, but may not address customer needs for adequate root cause diagnosis. It is therefore important to reduce the bias that could be introduced due to the frame of reference of the model builder (a business or technical analyst, or other member of the cross-functional decision making team). Adequate representation of multiple stakeholder groups in the model-building sub-team may reduce frame of reference bias. In addition, historical data, combined with healthy debate among the stakeholders about decision criteria, importance weightings, decision alternatives and individual ratings could help reduce the “frame of reference” bias during decision making.

6. IMPLEMENTING CHANGE IN THE ENTERPRISE

"Change is the law of life. And those who look only to the past or the present are certain to miss the future."

- *John F. Kennedy, address to Assembly Hall in Frankfurt June 25, 1963*

As President Kennedy pointed out, change is inevitable in every enterprise, be it the United States of America, or a small start-up company. While the pace of change might differ in different circumstances, every enterprise must be prepared to change according to its clockspeed.[47] High-tech enterprises will need to pay particular attention to the shorter product clockspeeds that are inherent in their industry (since that could determine the process and organizational clockspeed). This is important since the shorter the industry clockspeed, the shorter the time available to make decisions. Product lifecycles in high-tech are typically of the order of 18 months, requiring firms wanting to stay competitive to evolve their products at that rate. To support this product evolution, development and manufacturing processes may need to evolve rapidly, and virtual or actual organizations may need to form and reform around the product lifecycle. The pace of decision making and implementation of change needs to be align with such clockspeeds to ensure the most benefit to the products, processes and organizations currently in place. In this chapter we discuss some of the challenges that could be faced by companies trying to implement change within their enterprises.

6.1. Organizational dynamics can aid or hinder change

The dynamics of organizations within the enterprise often indicate how individuals (or groups) interact with other individuals (or groups) and behave under specific circumstances. This is partly influenced by the structure, politics and culture within the enterprise, and partly by the individual's perspectives or frame of reference within different situations. The manner in which organizational dynamics are managed or considered within a change management program can influence the outcome and success of the program.

[47] Clockspeed refers to the rate of evolution (in product, process, and organization). Charles Fine discussed the concepts of product, process and organizational clockspeed in his book:
Fine, C. Clockspeed: Winning Industry Control in the Age of Temporary Advantage. Perseus Publishing, 1998.

6.1.1. The Three Lenses: Strategic Design, Political and Cultural

Individual and group interactions and behaviors can be understood using the Three Lenses organizational behavior framework developed at the MIT Sloan School of Management.[48] Each of the three lenses shown in Figure 9 is a different perspective on the organization that highlights the functions, meaning and information within organizations. By considering each organization through a combination of the three lenses, one could determine whether one of the lenses was not considered when designing the organization, leading to challenges and resistance when implementing change within the organization.

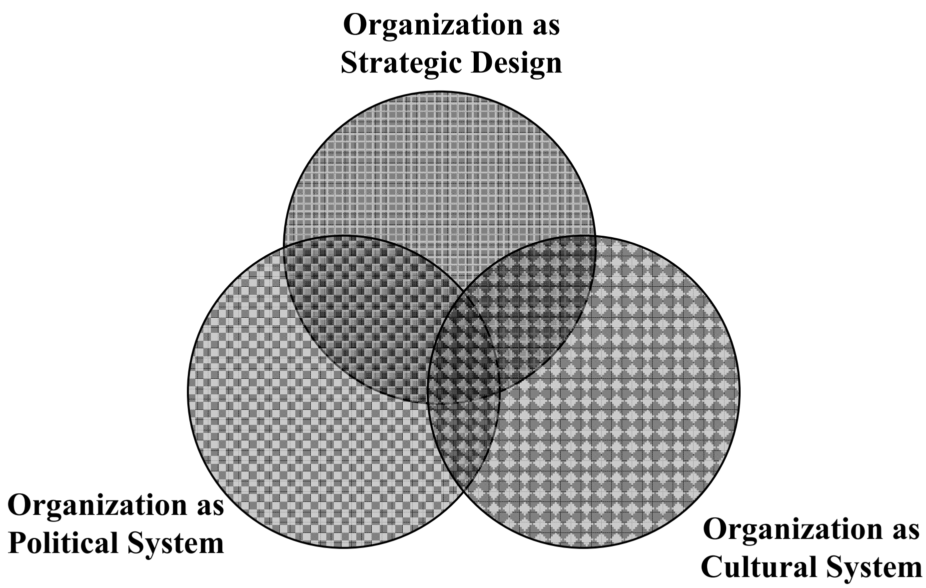

Figure 9: The Three Lenses – Strategic Design, Political, Cultural

1. Strategic Design Lens

The Strategic Design lens considers the organization as a machine intended to achieve "goals" by carrying out "tasks". The organizational designers and management have a "strategy" for the organization based on opportunities and capabilities. Consider for example, a typical high-tech firm that consists of business units responsible for products and functional groups responsible for activities and tasks as shown in Figure 10. While each of the organizations may have different hierarchies, their primary reporting structure is vertical. The HR and IT functions are aligned

[48] Carroll, J. Introduction to Organizational Analysis: The Three Lenses. Revised July 2002.

with each vertical group (e.g., HR for Manufacturing, HR for Development, HR for a specific business unit etc.), with little cross-pollination within these support organizations. Each organization (product focused business unit and functional group) is responsible for specific tasks that contribute to the goal of increasing revenues and profits for the firm. This organizational structure forms a "strategic grouping" around specific tasks, with individuals in each organization able to share knowledge, experience and expertise within that specific organization, thus improving the organization's capability.

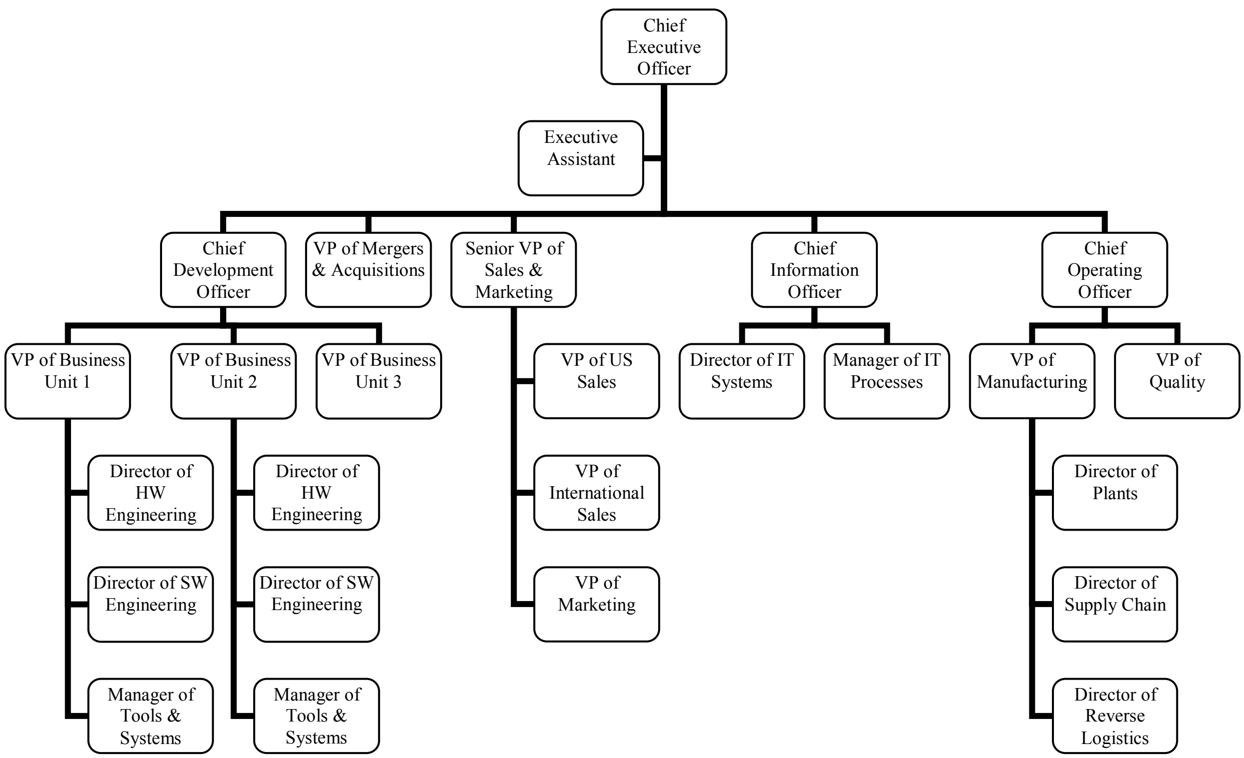

Figure 10: Example of a vertical organizational structure for a firm with business units and functional groups

Many firm managers believe that by regrouping the individuals into new structures (i.e., changing the organizational chart), they can change the organization. Unfortunately, such managers fail to consider that "organizational silos" can be created in strategically grouping people by function or product focus and some "linking mechanisms" need to be developed to bridge the gaps between these groups. Some organizations try to create "matrix" like structures with vertical reporting relationships but "dotted-line" relationships with supported groups. Some companies use cross-functional councils or process improvement initiative teams to link stakeholders from each group. They may further group members by business process, with sub-teams focused on specific tasks and stages in higher-level activity. Such cross-functional councils may also have a formal vertical hierarchy, reporting to a cross-functional board of executives and ultimately to the executive officers or Board of Directors of the firm. However, as is often the case in cross-functional councils, each member also formally reports through his or her individual functional group hierarchy. Informal linkages may exist among members of specific sub-teams depending on the task and activity being performed. A RACI chart could be used to define responsibilities and functionally align team members to tasks.[49] In addition, a project manager or Six Sigma coach may form links among specific team members. While some firms effectively use IT databases and common tools (e.g., Microsoft SharePoint) to support linkages among team members, in firms where sub-teams are extremely focused only on their tasks, "information silos" could develop within the cross-functional council.

In most firms, different groups want different things and may be rewarded for focusing on their individual tasks. As a result, members of cross-functional councils that belong to these different groups could disagree on the goals, tasks, direction and required change. It is therefore necessary to create "alignment" among the different individuals and groups. Such alignment could be created through a shared purpose (e.g., all members want to improve the failure analysis system), through formal mandates (from the top down), through performance metrics for achievement of the team's goal, or through informal networks. Informal networks, such as those formed by people of similar backgrounds or interests, form a critical element of most large enterprises and are often used to facilitate completion of tasks and implementation of change. In some cases, team members involved in cross-functional initiatives may have responsibilities added-on to their routine job function and individual incentives may not necessarily aligned with initiative success-measures or corporate-level metrics. Such organizations will need to deal with monumental change management efforts during implementation of new systems or processes. In companies with hybrid top-down "inverted U" hierarchy and informal social networks, a combination of top-down change and lateral socialization of new concepts and processes will be necessary to ensure that changes are effectively implemented across the enterprise.

[49] RACI is a management tool used to identify the roles and responsibilities of team members or groups. R = Responsible, A = Accountable, C = Consulted, I = Informed.

2. Political Lens

The Political lens views the "organization as a contest for power among stakeholders having different goals and interests". This lens moves beyond the formal groupings within organization to combine individuals or groups with similar interests and goals into "coalitions". Goals and strategy are either imposed by a ruling coalition or negotiated among stakeholders. Different stakeholders have different "power bases" or sources of power. These may be based on their position in the hierarchy, their experience in the industry, their knowledge, the resources they control, how many people they have in their coalition or the influence they have over individuals and groups.

In companies with functional silos, individual hierarchies can develop that formally determine power within the function based on tenure and position within the hierarchy. The perceived importance of the function in driving revenue and profit may yield more power. For example, in high-tech firms of the 1980s and 1990s, engineering expertise and sales or marketing capability was often valued more than cost-containment since these functions attracted more customers and "sold" the products based on technical capability and "coolness" of features. In such firms, the engineering and sales and marketing functions held more power than a manufacturing organization which might have been treated as a support function that simply executes after decisions have been made. However, this trend may be changing with recent market pressures and increased global competition making cost-containment a valuable competitive capability. In other enterprises, power may lie with those formally designated as "gatekeepers" of information. In such cases, limited knowledge may be shared with team "outsiders" on a "need to know" basis for their support in driving decisions.

Sometimes power struggles can be detrimental to the long term success of initiatives. Employees may conduct work on projects "under the radar" to avoid having to deal with power struggles. As a result, it may not always be clear which stakeholders have specific information or are working on specific activities. Furthermore, informal power across the functional silos may be determined by tenure and social or professional networks developed by individuals with each function. New team members with limited experience within that specific enterprise may require more time to build their informal power within the team. On the other hand, stakeholders who recognize the power base within specific organizations may be able to use informal networks to gain access to data, to influence change and to drive implementations from the "bottom-up" rather than waiting for mandates or executive announcements.

Another effect of the functional silos is goal conflict that can be created in cross-functional teams. Each functional group may try to focus the deliverables and outcome of the initiative on the benefit that the group will gain from the activity of the team. Some groups may view cross-functional initiatives (such as the FA supply chain design) as "goldmines", yielding significant recognition to the involved individuals and maximum benefit to their organizations. Lack of incentive alignment at the management level may further exacerbate this situation. For example, if the primary goal of an organization is to focus on developing new products rather than supporting existing products, their level of commitment to systemic changes in the "product support" areas may be limited. Geography can also exacerbate the situation. For example, if new initiatives are driven by headquarters based in the US, with few mechanisms for non-headquarters based groups to have direct input into the initiative or the change that needs to be implemented, it is unlikely that the change will be easily adopted. Alignment of interests among stakeholder groups that are impacted by changes is crucial to the success of change implementation activities.

Although recognition of these goal and incentive differences will allow stakeholders to better appreciate the levers they have to influence the outcome of collaboration on any initiative, all stakeholders need to understand these differences. Conflict resolution should be handled through formal and informal mechanisms that protect stakeholders with less power from being dominated by other stakeholders with more knowledge and power. For example, an understanding of why past attempts at changing something (a system, a process, or an organization) failed will allow teams to drive change through involvement, collaboration, and influence rather than brute force.

3. Cultural Lens

The Cultural lens assumes that "people take action as a function of the meanings they assign to situations". History, language, cultural norms, "war stories," and experiences form the basis for the meanings which are generated and shared among members of a group and passed on to new members. As in many countries, organizational cultures also develop over time as traditions are created which represent "what we do, how we do it and why we do it". Some companies designate formal norms while in other companies, the norms are created as the organizations grow and evolve over time. In some firms, norms are widely shared, such as in the case of Cisco, where formal cultural norms and values are outlined on every employee's badge shown in Figure 11. In other cases, culture may be "localized" to specific groups like marketing or engineering based on their experiences. Even in firms where norms are widely shared, some norms may become more prevalent than others, in part due to the company's historical evolution. For example, Cisco became profitable and grew through acquisition of innovative start-up firms and cutting edge technology across the high-tech industry. As a result, significant emphasis is placed on innovation, especially within the engineering community. The acquired businesses are often provided organizational autonomy to allow them to continue innovating, and these businesses have or develop their own internal culture within the larger parent company. Companies like Cisco however need to be wary of encouraging a hierarchical and silo'd ("us" versus "them") culture in such situations. This becomes increasingly important when direct control over some functions (e.g., manufacturing plants) ceases as the functions are outsourced (e.g., to contract manufacturers). In such cases, the organizations need to ensure that they treat the outsourced provider consistently, without having some functions treating them as partners and other functions maintaining a stronger directive, oversight relationship with them.

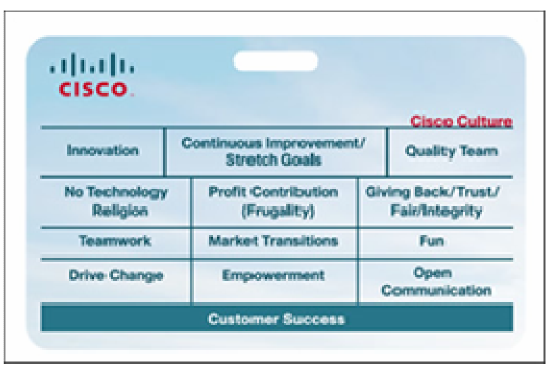

Figure 11: Cisco employees wear badges describing the company's culture and strategy

Newcomers in many firms hear of the "Company Way" (e.g., "The HP Way", "The Cisco Way", "The GE Way") of doing a task, activity or function. For example, in many high-tech firms prevalent culture encourages innovation which drives growth, but discourages processes due to the perception that "processes stifle innovation".

Although cultures develop over the history of the firm (or the industry), it is important to realize that cultures can be changed. However, it often takes a champion to challenge the basic assumptions and norms held by the existing organization. New executives may be able to change perceptions that exist (e.g., "processes are inherently bad for growth" or "manufacturing is a necessary support function but non-value added") within the company. However, such champions need to gain commitment from their peers in order to influence not just their direct hierarchy but the entire enterprise. In addition, they can seek influential "outsiders on the inside" to help inject new perspective into the prevalent culture.[50] For example, employees who are currently in executive management programs or continuing education programs at academic institutions can bring "outside" perspectives from academics into their existing organization and influence their peers, managers and subordinates to stretch their narrow view of functions and evolve decision making within the organization. Such "outsiders on the inside" can view the organizational challenges from an external perspective, while driving change internally within the existing culture.

6.1.2. Frame of reference of stakeholders can determine success

In Chapter 5, we discussed how the "frame of reference" of team members involved in decision making can influence the outcome of the decision. Similarly, the frame of reference of stakeholders involved in implementation of the decision can influence how successfully the change is adopted by the organization. Consider for example a new initiative that has been launched to change an operations system that introduces new processes and requires groups to work together in different ways. Some of the stakeholders have been within the company for several years and have experienced numerous re-organizations. Furthermore they have seen two prior attempts at changing the operations system terminated. One of these attempts was driven by the engineering organization and the other by the manufacturing organization. In the first case,

[50] For more information on "outsiders on the inside", see: Klein, J. True Change: How Outsiders on the Inside Get Things done in Organizations. John Wiley and Sons, 2004.

the engineering organization developed the new, “improved” system and expected that the manufacturing organization would support them later. In the second attempt, the manufacturing organization took “ownership” of the problem, involved the engineering organization in designing the new system and started to implement the change. However, they found that the recommended changes were too expensive to implement and they encountered resistance from other functional groups who were not involved with the design. If the stakeholders look at the partial success of these attempts purely from their individual “frame of reference”, they might attribute the challenges to the other groups “not getting it” or to quality, not cost, being a major competitive advantage. On the other hand, the groups that were not involved might have viewed the project as “non-value added”, “just another fad of the month” or “some executive trying to show off” and may have been reluctant to get involved. Despite these perspectives, the underlying root cause of the challenges that the prior attempts encountered might have been lack of cross-functional ownership, limited stakeholder involvement or poor implementation of changes (i.e., lack of follow through).

As the example shows, it is important for executives and teams that launch new initiatives to involve the impacted stakeholders and ensure cross-functional ownership of the initiative throughout the life of the project. In addition, it is important for the team leaders and other team members to understand the different “frame of reference” that each group brings to the initiative. By appreciating that the “engineering frame of reference” may be different from the “marketing frame of reference”, the “IT frame of reference” or the “manufacturing frame of reference”, the team can ensure that the decisions made are not biased towards one group at the expense of another group. This will allow the collective group to commit to the recommended change and for team members to act as champions of change within their respective organizations. Such champions are uniquely positioned in that they understand their reporting group’s “frame of reference” and also appreciate how this might need to evolve to align with the rest of the company. In this way, bottom-up change can be instituted by the team responsible for driving the initiative, by overcoming resistance through their informal network and experience within their formal organization and in the cross-functional team. It should be noted that the individual team members in the cross-functional team need to be supported by their immediate management and by executives within their individual organizations. Furthermore, selecting an experienced person (or someone with informal influence) to represent the organization will increase the likelihood of success for the change.

Commitment from senior management is important for the success of the change implementation. Senior management needs to recruit and develop leaders capable of instituting change through collaboration and influence. However, such executives and change-originators need to be wary of the perception that the change initiative is a "flavor of the month" within the company. Furthermore, the team needs to encourage and nurture outsiders on the inside who are capable of driving change while navigating the intricacies of the political environment and existing cultural norms. Some companies extensively use external consultants to "think for the organization" when they want to change their strategy or re-design an operational process. Such consultants often bring a different "frame of reference" based on their experience in other companies, industries or change management initiatives and can be valuable advisors to the company. However, without effective integration into the organization and the cross-functional team leading the change initiative, the expertise and recommendations of the consultants will not be fully utilized to benefit the company.

"Frame of reference" differences can be reduced through incentive alignment. Alignment of individual incentives with success metrics for the initiative and corporate goals will minimize the differences and help drive the correct behavior among stakeholders. Well meaning individuals can be encouraged to drive change at the working level by aligning their efforts with common goals and strategic needs of the company. Proactive, collaborative conflict resolution at the individual and group-level can help break down barriers created due to different "frames of reference". Stakeholders should be encouraged to learn from past failures and avoid repeating past mistakes. Individuals who can develop a big-picture perspective while addressing the tactical issues will be able to achieve this learning and alignment with corporate goals.

6.2. Define and document the policies and processes

In addition to the organizational challenges that need to be addressed during implementation of change, companies who want the change to be adopted should define and document the new policies and processes. The cross-functional team leading the change initiative should gather input to define the policies in accordance with company strategy and goals of the initiative. Process documentation should be a collaborative effort between the cross-functional team and the individuals or groups that will be involved in the process. Rather than institute a "big bang" change with an executive announcement followed by extensive training for those affected, involving individual stakeholders who will be impacted in the new process development and documentation will accelerate buy-in and rate of adoption of the change.

The new policies and processes should be shared widely across the enterprise (as allowed by confidentiality agreements). This will allow stakeholders to provide feedback, develop a common baseline "frame of reference" with respect to the new system, and eliminate confusion that often results from lack of documentation or access to relevant documentation. In addition, the policies and documentation should clarify what the resolution mechanisms are for borderline cases that may not have been documented but could arise during day-to-day operation. This can be followed by mandatory and optional user training for stakeholder groups that are involved in the new system. The policies and processes should be phased into the organization using a step-wise approach with a clear "cut-over" date identified well in advance for adoption by the entire enterprise.

6.3. Conduct pilot programs to evaluate changes

Many large companies conduct pilot programs to evaluate the effectiveness of changes. Such pilot programs can be conducted when implementing new IT systems or processes. For example, if the new failure analysis supply chain requires a collaboration tool, such a tool could be tested among a small group of users prior to large scale rollout. In addition, high tech firms have started to experiment with RFID in their supply chain (for visibility) and IT organizations (for asset tracking). In some cases, a functional group or organization may volunteer to become a pilot, while in other cases the group is selected based on some pre-defined criteria. In order to study the effectiveness of any change, metrics should be defined prior to starting the pilot, measured during the pilot and evaluated at the end of the pilot. However, any enterprise that implements a pilot program should be wary of using the success of the pilot as the sole indicator for the success of the larger implementation of change. Some of the drawbacks of pilot programs include:

1. Organizations that volunteer for the pilot often have a senior executive championing the program and ensuring that incentives are aligned for success of the pilot. This may not be the case across the entire enterprise when the large scale change is implemented.
2. Organizations that volunteer or may be selected for the pilot may have already committed to the change, either completely or partially, and are willing to put in effort to make the change happen. In general, commitment is not universal across enterprises and the large scale change implementation team may run into more resistance than observed during the pilot.
3. The systems impact of a pilot program may be limited to the scope of the pilot (e.g., the addition of a collaboration tool may involve some work around within the pilot organization). However, the systems impact in a broader enterprise-wide change may be larger and require more resources and attention.
4. Performance metrics selected for the pilot may not be relevant to the broader enterprise. In some cases, metrics are selected for the pilot using feedback from the organization that volunteers for the change. However these metrics may not be captured by the other organizations in the enterprise and the proper incentives may not be offered to these organizations. Thus, the broader change may not be as effective as the pilot based on the measurement against these performance metrics.

6.4. Other considerations during implementation

In this section, we highlight some of the other considerations that all enterprises, and high-tech firms in particular, should be aware of when implementing changes.

6.4.1. Interactions with outsourced partners' established processes

Outsourcing is an increasingly common phenomenon in the high-tech industry. Manufacturing, design, logistics, HR, IT, and sales may be some of the functions that are outsourced to third party "partners", while the company focuses on its core competency. In such virtual enterprises consisting of numerous partners interacting with each other, it is important for the company recommending the change to gain buy-in from some (or all) of their value chain partners. Each of these partners has established processes and “ways of conducting business”. Any change to the company’s processes and systems may impact the partners’ processes and systems and require the partners to adapt. If the company is an important customer, partners may be willing to accept the impact. However, if the company is a small player in the industry, the partners may be reluctant to change. In addition, new systems may require minor or significant changes to partners’ operations, and incur additional costs that may be passed on to the company. Thus, it is in the company’s best interest to negotiate the changes and associated costs with partners prior to large scale implementation.

6.4.2. Principal-agent problem in outsourcing

This classic economics problem is inherent in any outsourcing relationship.[51] The outsourced partner (agent) conducts some activities for the company (principal). However, the agent’s actions may not result in the performance that the principal desires. This may be because the actions that the outsourced partner carries out may not be directly correlated with the performance desired (e.g., the partner tries to maximize its own profit rather than that of the company). Alternatively, it may be that the incentives provided to the partner are not aligned with the desired performance (e.g., if partners are paid on a cost-plus basis, there is little incentive for them to reduce costs). A third possibility is that there is asymmetric information within the relationship and costs for monitoring the partner may be too high (e.g., the company cannot rely on the partners’ loyalty to do the “right thing” in a competitive environment, but oversight may require additional resources that the company would need to hire). Thus the company needs to ensure that any changes that they would like to implement are recommended in conjunction with new incentives that produce the performance that is desired. This can be particularly challenging if the impact of the changes cannot be quantified prior to negotiations. Nevertheless, if the company maintains a long-term outsourcing relationship with the partners

[51] There have been a number of papers and books published on the principal-agent problem in outsourcing-relationships. A perspective on this economics issue in engineering-outsourcing can be found in: Keil, P. "Principal Agent Theory and its Application to Analyze Outsourcing of Software Development." Proceedings of the Seventh International Workshop on Economics-Driven Software Engineering Research. St. Louis, Missouri, May 15, 2005.

(through ups and downs in the market), incentive alignment can be improved and partners can be encouraged to implement changes that benefit the company (and thus the partner) over the long term.

6.4.3. Communication about change

Communication plans should be developed in conjunction with change implementation programs. In particular, communication policies for external stakeholders (customers, partners, suppliers) and internal stakeholders (management, business units, functional groups) need to be aligned to ensure that a consistent message is being delivered. The communication plan should outline the frequency of communication, reasons for the change, timeline for the change, and expected actions from stakeholders to support the change program. Communication may be made by the team leading the change, by individual stakeholders or by the executive management team interacting with each stakeholder. Although the communication may be in the form of a formal memo, a customer announcement, email from the team, individual phone discussions or on the company's internal website, at least one formal announcement should be made to all stakeholders by a senior champion for the project. Regardless of the mechanism for communication, the message should be consistent with the goals of the initiative and should be agreed to by the cross-functional team of representative stakeholders. This will enable the entire enterprise to prepare for the change, voice its concerns, provide feedback and ultimately make changes to its way of performing related activities. In addition, the communication plan, if successfully implemented, could serve as a template for future change programs and benefit the company from standardization in their communications process.

6.4.4. Training across the enterprise

Most successful change initiatives are accompanied by training programs for the impacted stakeholders. These programs can be formal or informal, in a classroom setting or on the Internet, for groups or for individuals. However, the basis of the training should be to share the changes that are being made, how they impact the individual stakeholders, describe or discuss how changes in their activities can be made to implement the new system or process and allow them to experiment and share knowledge across the enterprise. In order for the training to be effective and for employees to be in an open frame of mind when attending such sessions, managers should provide adequate time away from the individual employees' normal duties to participate in the training. Such additional time provides an incentive to the individual employee, who might otherwise be reluctant to take on "additional work" without any perceived benefit in the short term. Involvement and engagement of all stakeholders will improve the likelihood of adoption of the change and success of the initiative over the long run.

7. RECOMMENDATIONS AND CONCLUSION

7.1. Key recommendations for the high-tech industry

This thesis has highlighted some of the challenges that high-tech companies like Cisco need to overcome to manage product returns, failure analysis systems and address customer satisfaction issues. In this section, some of the key recommendations to address these challenges are discussed and summarized.

7.1.1. Competition and changing industry dynamics require continuous operational improvements

High-tech companies today are dealing with shorter product lifecycles and increased global competition. In addition, changing customer demographics from primarily large enterprises, to a mix of large enterprises, small and medium businesses, consumers, both domestic and international require companies to develop operational systems that cater to all customers. While significant emphasis has been placed on developing and delivering products to customers in the past, developing operational excellence in product returns management, failure analysis and closed loop corrective action will help a company achieve competitive advantage. However, competitive advantage can be temporary, as demonstrated by the rise and fall of such industry stalwarts as IBM from the 1960s to the late 1980s. In order for the competitive advantage to last for a sustainable period, it needs to be accompanied by continuous improvement and a drive to renew the business strategy based on changing market dynamics. Alignment of internal decision making with evolving business strategy and flexibility in decision making processes and tools will help the company adapt to dynamic environments and continue to improve its operations.

7.1.2. Product returns management is important for customer satisfaction

As many high-tech companies have discovered, managing product returns is often complex and expensive in a globally networked supply-chain environment. Product variety, geographic diversity, outsourcing, multi-tier failure analysis, inadequate returns gatekeeping and disparate information systems contribute to this complexity. Multiple stakeholders, each having its own core competencies must work together to reduce the negative impact on customers who have to deal with a failed product. However, as many of these same companies have discovered, the returns-related experiences of customers often affect customer satisfaction. Customers who deal with simpler returns processes may be more satisfied and willing to return to the same company than those who have to deal with more cumbersome processes. As a Harris poll conducted in 2006 indicated, 80% of consumers are "not very or not at all likely to shop again with the same retailer if the returns process is inconvenient."[52] Similarly, enterprise customers who use the high-tech company's products in mission critical applications would be even more concerned about the ability to replace, return and diagnose problems with the product than ordinary consumers. High-turnaround time, lost productivity, inadequate visibility, poor status-related information and inadequate root cause diagnosis can lead to customer dissatisfaction. With the large budgets associated with technology spending at these customers, recurring revenues from loyal customers can have significant financial impacts on the high-tech company. Managing product returns and implementing effective failure analysis processes to ensure good customer experiences will therefore be important to maintaining customer loyalty and sustaining financial stability and growth.

7.1.3. Re-architecting the supply chain requires defining a vision

Companies that have tried to develop a supply chain (forward or reverse) without a clear vision and purpose in mind have often found themselves trying to sort out structural and relationship issues later in the process. In contrast, companies who define a vision for their supply chains are able to identify the needs of their customers and internal enterprises, and the value needed by all the stakeholders in the supply chain. They can then architect or re-architect their supply chain structures and develop relationships among stakeholders to encourage collaborative, value-added behaviors that improve the operational and financial performance of all stakeholders in the supply chain. In addition, it is important for companies to consider the impact of new architectures on their business strategies and ensure that the vision for the supply chain does not introduce new constraints that would make companies less competitive over the long run.

---

[52] "Reaping the Returns: Convenient Returns Process Helps Retailers Ensure Customer Loyalty." 2006 <http://www.harrisinteractive.com/news/newsletters/clientnews/2006_Newgistics2.pdf>.

7.1.4. Holistic perspective adds value during failure analysis supply chain architecting

Historically, companies have treated their failure analysis supply chains as incidental add-ons to their forward supply chains, often dealing with necessary but "low value-added" business processes. As such, traditional approaches to failure analysis supply chain design fail to account for the complexity involved with multiple stakeholders, product and geographic diversity, outsourced relationships and disparate information systems. By taking a more holistic, enterprise architecting approach to failure analysis supply chain design, high-tech companies can re-architect their systems to address the governance, process, network design, organizational and cultural issues while implementing enabling technology and performance metrics that enhance the value-added characteristics of the system. In addition, best practices can be applied to existing and new processes to improve the effectiveness and efficiency of the failure analysis system. Sharing of best practices and internal knowledge across functions and business units through formal and informal channels such as steering committees, business councils, seminars and brown-bag forums, can facilitate implementation of value-added processes.

7.1.5. Decision making can be complex and needs to consider frame of reference of stakeholders

Decision making is an integral activity within most enterprises, small and large, technical and non-technical, public and private, individual and team based. Decisions can sometimes be difficult to make, especially when there are a number of criteria to consider, vast amounts of data exist for very complex systems, and perspectives of decision-making stakeholders differ. In such environments, computer-based models and decision support tools can be helpful to sort through the data, discuss different perspectives and optimize the decision based on which criteria are most important to achieve the objective of the team. As demonstrated by the "Decision Model for Failure Analysis Supply Chain" decision support tool, decisions among different alternatives can be made based on objective-driven criteria, risk factors and historical and projected data to select the "most optimal" network. Skilled analysts and modelers can help model complex supply chain strategy decisions and adapt existing tools to the needs of the decision making team. In addition, documentation of decisions made using tools and models can help provide baseline references for future decisions. Decision support tools and documentation can be shared across the enterprise in searchable common knowledge databases. Decision support tools and models allow for more data-driven decision making that can reduce the organizational resistance when implementing change.

It is not uncommon for teams within technology companies to consist of independent stakeholders who are creative but have strong opinions about decisions to be made by the team. Such opinions may result from their individual personal, political and cultural experiences, their functional or technical expertise, their position in the organizational hierarchy, or their reputation within the team. Each of the stakeholders enters the decision making process with a specific frame of reference and approaches the information, criteria and objective from this perspective. By considering the frame of reference of the stakeholders during decision making, the team can determine whether any bias was introduced into the decision and how that bias impacts the outcome of the decision. This will be particularly important as the team starts to implement the changes resulting from the decision outcome across the diverse set of internal and external stakeholder organizations.

7.1.6. Data integrity and accuracy can help improve decision making capability

Many high-tech companies grew at a rapid rate during the 1990s technology boom. As a result, they often scaled their operations through acquisition of companies, implementation of new systems, or addition of supply chain partners. In many cases, the entire networked enterprise might have multiple, disparate information systems that capture different types of data, restrict access to specific users and store data in different formats. Integrating data from such disparate systems is important to eliminate manual processing labor and the possibility of human error. In addition, data integrity is important to ensure that the correct information is utilized in decision making. Incorrect data or reconciliation of data from different systems can increase decision making time and sometimes yield unexpected, non-optimal results. Thus it is important for companies to cleanse the data that exists in their information systems, link or integrate as many systems as appropriate to share the right data necessary for failure analysis (e.g., product and manufacturing information for the returned product) and automate the reporting of performance metrics for ease and accuracy of decision making. In situations where data cleansing and integration may be underway, data could be shared through other knowledge sharing portals within the enterprise. In addition, key stakeholders could gather appropriate data, fill data gaps, assess the level of accuracy of data, and determine if multiple levels of analysis are needed prior to the final decision being made.

7.1.7. Consider the organizational dynamics prior to implementing change

Organizational change is difficult, especially in large enterprises that are organized into functional silos to optimize the efficiency of their function. By considering the organizational dynamics from a Three Lenses perspective prior to implementation, companies can ensure that the strategic design, political and cultural barriers are minimized, and stakeholders are open to accept the change. To avoid "hot potato" behavior regarding important projects resulting from too many organizational changes, the company should clarify the organizational changes along with roles and responsibilities (using tools like RACI charts) as quickly as possible. This should be accompanied by aligning incentives of the stakeholders with project success in addition to their individual performance in regular duties. Companies that understand the frame of reference of each affected stakeholder (or stakeholder group) can phase in a change program in a manner that reduces resistance from these stakeholders. By encouraging cross-functional collaboration among stakeholders, the company could not only break down silos, but could also benefit from reduced bias in decision making and shared best practices across the entire enterprise. The company could change "not invented here" culture through actively utilizing the frame of reference of outsiders (such as consultants) and outsiders on the inside (i.e., internal stakeholders who can maintain an outside perspective). However, outsiders cannot drive sustainable change, and insiders should be encouraged to pull change through demonstration of "small wins", exposure to outside perspectives, and empowerment by their management to initiate and support change programs.

Implementing change within a virtual, networked enterprise consisting of numerous supply chain partners is significantly more challenging than in vertically integrated enterprises that do all the work themselves. It is therefore important to manage stakeholders within the virtual enterprise as essential business partners who can add value. Aligning the incentives of outsourced-partners within the supply chain with the desired behavior will facilitate adoption of the change. "Champions of change" can be nominated within each stakeholder group to manage the change implementation. Companies who need to manage changes across virtual enterprises can benefit from a change roadmap that highlights the actions, phases, milestones and plan for implementing process and supply chain changes. Definition and documentation of new policies and processes, communication of the changes, training associated with the changes and demonstrated value add (through pilot programs) will engage stakeholders and improve the likelihood of successful change.

7.1.8. Automation can improve efficiency of returns processes

Although the high-tech industry develops some of the most advanced products in use today, the industry appears to be a late-adopter of automation technology. By contrast, supply chain enterprises like Wal-Mart and the U.S. government are leading the widespread use of visibility and tracking technology such as RFID. High-tech companies like Apple, Cisco, Dell, IBM, and Sony that develop and market numerous products around the world can benefit from monitoring products in their installed base and tracking returns from the field using barcode and RFID technology for ease of gatekeeping, failure analysis and disposition or re-introduction into spare parts inventory. Similarly, warehouse management systems offered by companies such as SAP, Catalyst, Infor and Red Prairie[53] can help automate the supply chain activities within the receiving dock, warehouse and shipping dock. Such systems can be implemented by multiple supply chain partners and synchronized with the high-tech company's core enterprise resource planning (ERP) system to provide financial and operational visibility. Such synchronization also allows companies to set up business rules for gatekeeping, processing exceptions, and proactively identifying problems in the receiving and shipping processes. Some systems can automatically generate shipping labels based on a barcode or RFID tag that is scanned, thus minimizing human error and processing time at shipping docks.

---

[53] There are numerous software vendors and consulting firms offering warehouse management solutions. The vendors listed here are meant to be representative are not necessarily endorsed. Each company should implement the solution that best satisfies their needs and constraints.

In addition to implementation of automation technology, process and operational changes can be made to improve effectiveness and efficiency of returns processes. Return material authorization (RMA) can be used in conjunction with barcode technology to improve gatekeeping of product returns. Automated or semi-automated cross-docking at the returns depot[54] could reduce the human labor necessary at the returns depot and eliminate processing and inventory holding costs traditionally associated with manual processing within the depot. Cross-docking, if used with regular drop-off and pick-up intervals negotiated with the logistics providers, could provide predictable delivery times and smooth the operation of the returns depot. This allows the company to utilize “virtual centralization”, thus gaining transportation efficiencies of scale.

7.1.9. A Lean culture can improve effectiveness and efficiency of operations

High-tech companies can benefit from a Lean[55] culture focused on continuous improvement (kaizen) within their forward and reverse supply chain operations. For example, value stream mapping, a Lean principle, when used with waste-walks by employees within the operations can be effective at identifying and eliminating wasteful activities. The principles of 5S can help organize the office work space, factory floor, warehouse space, shipping and receiving docks. Visual control boards can be utilized to display key performance indicators and performance to goal. Such boards can be used to identify expected processing times and identify types of product returns that cause delays in processing. These exceptions could be handled on a separate processing line or more labor may be applied to process them. Visual boards could also increase communication among operators and encourage them to troubleshoot problem areas together. Tools such as design structure matrix (DSM) can help re-organize process flows to reduce dependencies of tasks and optimize the shipping, receiving and processing operations. Jidoka can be used to automatically detect errors during processing and help identify ways to achieve operational goals. Heijunka (“leveling”) could be applied to returns and failure analysis processes to reduce variability in labor required. Cross-training of employees in multiple

---

[54] This would allow the product received at a returns depot to bypass the storage warehouse and directly be routed onto an outgoing truck to the destination failure analysis site.

[55] Resources on the Lean philosophy, based on the principles of the Toyota Production System, include: "Lean Enterprise Institute" <http://www.lean.org> and "MIT Lean Aerospace Initiative" <http://lean.mit.edu> which conducts research that helps aerospace companies transform themselves into Lean enterprises.

functions could help address peak processing needs and facilitate leveling. Knowledge sharing among employees within each operation and utilization of "external" Lean observers across the value chain partners could identify solutions for common problems and improve productivity within the failure analysis value chain. Finally, Lean focus on customer value will help build a culture that is committed to exceeding customer expectations.

7.2. Recommendations for companies in other industries

Although the recommendations presented in this thesis primarily address the challenges faced by companies in the technology based industries, many of the recommendations are relevant to other industries. For example, the automotive and aerospace industries are highly dependent on electronics and control systems developed by the high-tech industries. Furthermore, they also encounter the problems of product returns and field failures of products that are used in mission critical applications and may have catastrophic consequences. As such, many of the problems and recommendations presented in this thesis are relevant to these industries. Companies in consumer goods industries such as retail apparel may have to deal with different customer expectations and different supply chain structures that include individual retail stores and wholesalers that sell a manufacturer's products to end-consumers. In such industries, recommendations specific to failure analysis may not be as important as they are for high-tech manufacturers. Nevertheless, recommendations relating to product returns management may be useful to improve efficiency of their operations. The general recommendations relating to decision making and implementation of change will be relevant to most, if not all, industries that companies operate in globally. However, before implementing any recommendations, each company should understand the structure of its industry and the needs of its customers and enterprise stakeholders. It should develop a decision making process that allows it to address challenges within its specific industry context.

7.3. Recommendations for future research

The research presented in this thesis was conducted during an internship lasting 6.5 months as part of MIT's Leaders for Manufacturing Program. As a result, it does not capture or discuss all of the possible issues relating to re-architecting failure analysis supply chains. Future research topics relevant to the failure-analysis supply chain include:

1. ***Modeling the impact of global taxes and trade on the returns supply chain***. Global trade is becoming an increasingly important consideration for high-tech companies who have operations and customers across national boundaries. In many cases, local and international regulations and tax laws are constantly evolving and could dramatically impact the outcome of any decision involving supply chain design.
2. ***Remanufacturing and value recovery***. While much of this thesis is focused on failure analysis and reporting of the results as being the end-point of the closed-loop communications process (with the customer), a number of companies could benefit from research that extends the frameworks to remanufacturing and value recovery (after failure analysis is completed). A significant amount of research has already been conducted on value recovery from excess, unutilized product returns that could be resold in secondary markets or utilized as spares. However, products returned for failure analysis could also be repaired or the components recycled in the used-parts stream and value recovered through resale of used, remanufactured parts.
3. ***Automation of the processes and systems within the reverse supply chain***. Although automation was discussed as being beneficial to operational efficiency, research could be conducted on the types of automation that benefit and hinder different types of supply chains (e.g., integrated versus modular supply chains).
4. ***Engaging contract manufacturer early in supply chain design***. In this thesis we recommend engaging all key stakeholders early in the supply chain decision making process. However, in situations where stakeholders (such as contract manufacturers) may be outside the enterprise and transactions with such stakeholders are arms-length, it may be difficult to engage these stakeholders upfront during supply chain design. Future research that incorporates economic modeling and organizational design could discuss how such arms-length stakeholders can be included in decision making without disturbing the formal corporate boundaries that may be necessary in specific industries.
5. ***Developing and training employees on cross-functional decision making***. An extension of this research project could involve identifying specific characteristics and environments that would be needed for cross-functional decision making. It could also

identify how employees can be provided the necessary skills and educated on the behavioral characteristics and culture that needs to be created to develop a collaborative, cross-functional decision making culture.

7.4. Conclusion

This thesis has presented an overview of the problems faced by high-tech firms within their global failure analysis systems, and proposed a holistic approach to re-architecting the failure analysis supply chain. A number of strategies have been recommended to overcome challenges that may be faced by leaders trying to implement change in their enterprises. Frameworks such as the "Reverse Supply Chain Architecture" and tools such as the "Decision Model for Failure Analysis Supply Chain" have been presented to allow operations leaders follow a prescriptive but flexible, data-driven approach to aligning the failure analysis supply chains with their customers' and enterprise's needs. The future is unknown, but holds much promise for companies truly committed to building world class operations enterprises. The strategies proposed in this thesis will aid managers and leaders in making monumental changes to their "reverse" operations and exceeding customer expectations for a sustainable competitive advantage.

8. REFERENCES

1. Ahmed, A. "A Holistic Approach to Reverse Supply Chain Planning for Remanufacturing." IEEE Proceedings of EcoDesign2003. Dec 2003.
2. Bernus, P., L. Nemes, and G. Schmidt. Handbook on Enterprise Architecture. Springer, 2003.
3. Best Practices in International Logistics. Manhattan Associates and Aberdeen Group, 2006. <http://www.manh.com/library/MANH-INSIGHT_Best_Practices_ILS.pdf>.
4. Blackburn, J. D., et al. "Reverse Supply Chains for Commercial Returns." California Management Review 46.2 (2004): 6-22.
5. Bowers, B. "Enhancing The Lean Enterprise Through Supply Chain Design: Establishing Reverse Logistics And Remarketing At A High Tech Firm." MIT LFM Thesis. 2003.
6. Carbone, J. "Supply Chain Manager of the Year: Steve Darendinger Champion of Change." Purchasing Magazine. Sep 21, 2006.
7. Carroll, J. Introduction to Organizational Analysis: The Three Lenses. Revised July 2002.
8. "CMMI General Information." Software Engineering Institute (SEI) at Carnegie Mellon University. 2007.
9. de Waart, D., and S. Kemper. "Five Steps to Service Supply Chain Excellence." Supply Chain Management Review 2004: 28-35.
10. "Dell recalls 4m laptop batteries." BBC News. Aug 15, 2006. <http://news.bbc.co.uk/2/hi/business/4793143.stm>.
11. Diane, A. M., and J. C. David. "The Hidden Value in Reverse Logistics." Supply Chain Management Review. July 2005.
12. Enslow, Beth. Grappling with Globalization: A Blueprint for Global Trade Management. Aberdeen Group, 2005. <http://www.aberdeen.com/summary/report/bvr/BVR_Globalization_BE.asp>.
13. Fine, C. Clockspeed: Winning Industry Control in the Age of Temporary Advantage. Perseus Publishing, 1998.
14. Fleischmann, M., et al. Reverse Logistics: Capturing Value in the Extended Supply Chain. 2004.
15. Fleischmann, M., J. A. E. E. van Nunen, and B. Graeve. "Integrating Closed-Loop Supply Chains and Spare-Parts Management at IBM." Interfaces 33.6 (2003): 44-56.

16. Fleischmann, M. Reverse Logistics Network Structures and Design. Vol. Reference No. ERS-2001-52-LIS. Erasmus Research Institute of Management, 2001.
17. Gecker, R., and M. W. Vigoroso. Revisiting Reverse Logistics in the Customer-Centric Service Chain. Aberdeen Group, 2006. <http://www.aberdeen.com/summary/report/benchmark/RA_RevLogReport_RG_3475.asp>.
18. "Guide to the Goods." Lands End Direct Marketers.1998.
19. Guide, V. D. R., T. P. Harrison, and L. N. van Wassenhove. "The Challenge of Closed-Loop Supply Chains." Interfaces 33.6 (2003): 3-6.
20. Hayes, R., et al. Operations, Strategy, and Technology: Pursuing the Competitive Edge. Hoboken, NJ: Wiley, 2005.
21. Keil, P. "Principal Agent Theory and its Application to Analyze Outsourcing of Software Development." Proceedings of the Seventh International Workshop on Economics-Driven Software Engineering Research. St. Louis, Missouri, May 15, 2005.
22. Kekre, S., et al. "Reconfiguring a Remanufacturing Line at Visteon, Mexico." Interfaces 33.6 (2003).
23. Ketzenberg, M., van der Laan, E., and R. Teunter. The Value of Information in Reverse Logistics. Erasmus Research Institute of Management, 2004.
24. Klein, J. True Change: How Outsiders on the Inside Get Things done in Organizations. John Wiley and Sons, 2004.
25. "Lean Enterprise Institute" <http://www.lean.org>.
26. "MIT Lean Aerospace Initiative" <http://lean.mit.edu>.
27. Murman, E., et al. Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative. Palgrave Macmillan, 2002.
28. Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.
29. Nightingale, D., and D. Rhodes. Lecture Notes from MIT Graduate Class ESD.38J Enterprise Architecting. 2006.
30. Norek, C. D. "Returns Management: Making Order Out of Chaos." Supply Chain Management Review 2002: 34-42.
31. Pall, G. A. The Process-Centered Enterprise: The Power of Commitments. New York: St. Lucie Press, 1999.

32. Pochampally, K., and S. Gupta. "Efficient Design and Effective Marketing of a Reverse Supply Chain: A Fuzzy Logic Approach." IEEE International Symposium on Electronics and the Environment. 2004.
33. "Reaping the Returns: Convenient Returns Process Helps Retailers Ensure Customer Loyalty." 2006. <http://www.harrisinteractive.com/news/newsletters/clientnews/2006_Newgistics2.pdf>.
34. Rechtin, E. Systems Architecting of Organizations. CRC Press, 2000.
35. Reverse Logistics Executive Council. Feb 1, 2007. <http://www.rlec.org>.
36. Roberto, M. "Why Making the Decisions the Right Way is More Important than Making the Right Decisions." Ivey Business Journal. 2005.
37. Rogers, D. S., and R. S. Tibben-Lembke. Going Backwards: Reverse Logistics Trends and Practices. Reverse Logistics Executive Council, 1999.
38. Schultmann, F., B. Engels, and O. Rentz. "Closed-Loop Supply Chains for Spent Batteries." Interfaces 33.6 (2003)
39. Shrivastava, S. Wipro Whitepaper: RFID in Returns Management in the Hi-Tech Industry. Wipro Technologies Ltd., 2005. <http://www.wipro.com/whitepapers/industries/manufacturing/rfid_returns_mgmt.htm>.
40. Souza, G. C., et al. Time Value of Commercial Product Returns. 2003.
41. Spengler, T., and M. Schröter. "Strategic Management of Spare Parts in Closed-Loop Supply Chains-A System Dynamics Approach." Interfaces 33.6 (2003).
42. "Supply Chain Operations Reference (SCOR 8.0) Model." Supply-Chain Council. <http://www.supply-chain.org>.
43. Tan, A., W. Yu, and K. Arun. "Improving the Performance of a Computer Company in Supporting its Reverse Logistics Operations in the Asia-Pacific Region." International Journal of Physical Distribution and Logistics Management 33.1 (2003).
44. Thrikutam, P., and S. Kumar. Infosys Whitepaper: Turning Returns Management into a Competitive Advantage in Hi-Tech Manufacturing. Infosys Technologies Ltd., 2004. <http://www.infosys.com/industries/electronics_hightech/white-papers/Returns_Mgmt.pdf>.
45. Tibben-Lembke, R. S. "The Impact of Reverse Logistics on the Total Cost of Ownership." Journal of Marketing Theory and Practice 6.4 (1998): 51.

46. Toktay, L., van der Laan, E., and M. de Brito. Managing Product Returns: The Role of Forecasting. Erasmus Research Institute of Management, 2003.
47. Trebilcock, R., Editor at Large. "Tighter Information Connections." Modern Materials Handling. 2005.
48. van Nunen, J., and R. A. Zuidwijk. "E-Enabled Closed-Loop Supply Chains." California Management Review 46.2 (2004): 40-54.
49. Vigoroso, M. W. Managing Service Chain Performance for Competitive Advantage. Aberdeen Group, 2005. <http://www.aberdeen.com/summary/report/bvr/BVR_Progistix_ServiceChainPerformance_020205_MV.asp>.
50. Vigoroso, M. W. Winning with Integrated Warranty Management. Aberdeen Group, 2006. <www.aberdeen.com/summary/report/benchmark/RA_WarrantyMgmt_MV_3181.asp>.
51. Walker, W. T. "Rethinking the Reverse Supply Chain." Supply Chain Management Review May/June 2000: 52-9.
52. White, C. D., et al. "Product Recovery with some Byte: An Overview of Management Challenges and Environmental Consequences in Reverse Manufacturing for the Computer Industry." Journal of Cleaner Production 11.4 (2003): 445-58.
53. Yadav, P., et al. "McGriff Treading Company Implements Service Contracts with Shared Savings." Interfaces 33.6 (2003).

9. APPENDIX

9.1. Appendix 1: Glossary

A number of terms have been used within this thesis. This glossary is intended to provide some commonly used definitions for these terms.

1. ***Acquisition:*** In the context of reverse supply chains, this is the process of acquiring returns from customers.
2. ***Closed Loop Corrective Action:*** The process of understanding root cause of failures, correcting the faults, and feeding information back to customers and other parts of the organization.
3. ***Contract Failure Analysis Site:*** A location of an external contracted party that conducts failure analysis on behalf of the contracting company.
4. ***Contract Manufacturer:*** An external contracted party that conducts manufacturing on behalf of the contracting company.
5. ***Decision Model:*** A framework or quantitative model utilized to decide among alternatives. It could be used to compare decision alternatives with respect to specific decision criteria.
6. ***Disposition:*** In the context of reverse supply chains, this is the process of determining what to do with products after they have been returned.
7. ***Enterprise Architecting:*** Enterprise Architecting defines the desired conceptual properties of an enterprise to be developed or evolved including purpose (or function), structure (or form), and top level conceptual design.[56]
8. ***Enterprise Architecture:*** Standards for the architecture of the product that define the products an architect must deliver and how those products must be constructed – without constraining the product content.[57]
9. ***Enterprise Architectural View:*** Perspective on the enterprise describing a related set of attributes.[58]
10. ***Failure Analysis:*** The process of diagnosing failures within products (or returns) and determining the root cause(s) of the failure.

---

[56] Nightingale, D., and D. Rhodes. Lecture Notes from MIT Graduate Class ESD.38J Enterprise Architecting., 2006.
[57] Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.
[58] Nightingale, D., and D. Rhodes. "Enterprise Systems Architecting: Emerging Art and Science within Engineering Systems." MIT Engineering Systems Symposium. 2004.

11. ***Failure Analysis Supply Chain:*** The complex system of sites, partners, IT applications and processes that supports failure analysis. This is usually a part of the reverse supply chain.
12. ***Fault Diagnosis:*** Process of identification and analysis of the problem(s) that caused a failure.
13. ***Frame of Reference:*** Perspective or point of view.
14. ***Functional Silo:*** Functional group that is separated from other functions (and is limited in its interactions with other functions). Individuals often interact with other individuals within the silo but are limited in their collaboration and growth outside that function.
15. ***Gatekeeping:*** The process of controlling access to a gate (or entry point). In the reverse supply chain context, it is the process of managing the point of entry into the returns management system. Gatekeeping involves understanding the reason why the customer is returning the product, only allowing products with valid problems and warranty coverage to be returned by customers, and collecting adequate information regarding the returned product to allow the company to process a replacement claim or provide proper credit to the customer.
16. ***Lean:*** A methodology of eliminating waste with the goal of creating value for enterprise stakeholders.[59] The principles of Lean were developed by Toyota and incorporated into the Toyota Production System.
17. ***Outsider on the Inside:*** Person within an organization (insider) who is able to see problems from an outsider's perspective.[60]
18. ***Returns Management:*** The process of managing products returned by customers and downstream supply chain partners.
19. ***Returns Management System:*** The complex system of partners, sites, processes and people that manage products being returned.
20. ***Returns Supply Chain:*** The supply chain involved with managing returns from customers and downstream supply chain partners.
21. ***Reverse Logistics:*** The logistics process involved in returning products to the company after sale or delivery to the customer.

---

[59] Murman, E., et al. Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative. Palgrave Macmillan, 2002.
[60] Klein, J. True Change: How Outsiders on the Inside Get Things done in Organizations. John Wiley and Sons, 2004.

22. ***Reverse Supply Chain:*** The process of planning, implementing and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.[61]
23. ***Supply Chain:*** The network of retailers, distributors, transporters, storage facilities and suppliers that participate in the sale, delivery and production of a particular product.
24. ***Value Recovery:*** In the context of reverse supply chains, it is the process of recovering value from returned products. This may include recovering warranty costs from suppliers for bad parts, disassembly of returns to reuse parts, reprocessing, refurbishing, and remanufacturing parts or products for remarketing in secondary markets or using as spare parts.

9.2. Appendix 2: Background on Cisco Systems, Inc.[62]

Cisco Systems, Inc. is the worldwide leader in networking for the Internet. Today, networks are an essential part of business, education, government and home communications, and Cisco Internet Protocol-based (IP) networking solutions are the foundation of these networks. Cisco hardware, software, and service offerings are used to create Internet solutions that allow individuals, companies, and countries to increase productivity, improve customer satisfaction and strengthen competitive advantage. The Cisco name has become synonymous with the Internet, as well as with the productivity improvements that Internet business solutions provide. In fiscal year 2006, Cisco announced revenues of $28.5 billion (84% from product sales, 16% from services related sales) and gross margins exceeding 65%.

Cisco's vision is to change the way people work, live, play and learn. The company believes the network is the source for experiencing this change, not just a network of computers, but a network of people. They launched a new brand management and advertising campaign describing this network full of potential, a gateway to new life experiences; a network of human connections. Their television and print ads describe the philosophy that we are more powerful together than we ever could be apart through their tagline "Welcome to the human network".

[61] Council of Logistics Management (now the Council of Supply Chain Management Professionals) definition.
[62] This information is obtained directly from Cisco Systems, Inc. website <http://www.cisco.com>, Cisco's Annual Report for 2006 and other public sources.

Cisco, together with its network of partners, develops, manufactures, sells and delivers hardware, software, and services to businesses of all sizes, governments, service providers, and consumers. Cisco believes that the foundation of their leadership in the industry is their strong emphasis on product innovation. Cisco innovates in many different ways: via technology development and the expansion of technologies after their initial invention, and through adjacent technology and market extension. Their long-time commitment is demonstrated by their investment of $4 billion in R&D during fiscal year 2006. The company also integrates and scales acquisitions, starts new business models, and partners with other companies. Cisco has acquired 114 companies since 1993 including its Linksys division and Scientific Atlanta subsidiary.

Cisco uses an extensive network of suppliers, original design manufacturers (ODM), original equipment manufacturers (OEM), and contract manufacturers (CM) to manufacture their products. In addition, logistics functions are typically outsourced to third party logistics (3PL) providers. Distributors, value added resellers and channel partners are used to distribute, integrate and sell solutions consisting of Cisco products. Cisco employs a number of supply chain managers, focusing on managing different strategies and relations.

An integral part of Cisco's business strategy is strong corporate citizenship. Responsible business practices help ensure accountability, business sustainability, and commitment to environmentally conscious operations and products. Social investments built upon partnerships with local organizations positively impact recipient communities around the world. These activities are designed to build trust in the company and empower the employees.

9.3. Appendix 3: Reverse Supply Chain Best Practices Framework

This reverse supply chain best practices framework was developed through a review of industry practices, standards and academic literature relating to reverse supply chain process improvement. Six major "elements" of the Reverse Supply Chain Architecture (shown in Figure 6 within section 4.3) create the framework for the best practices supporting design of a reverse supply chain. We recommend that specific best practices that are adopted by a company should align with the company's business strategy and goals. Best practices should supplement requirements gathered from customers and enterprise stakeholders.

Each architectural view (or element) has several sub-elements. An extensive list of best practices has been categorized within these sub-elements. This allows the architect to view the elements and sub-elements in isolation when determining which best practices are relevant to that organization's specific business and industry context.

9.3.1. Governance Best Practices Framework

The Governance architectural view can be divided into the 6 sub-elements shown in Figure 12. The Governance best practices are categorized by each of these sub-elements.

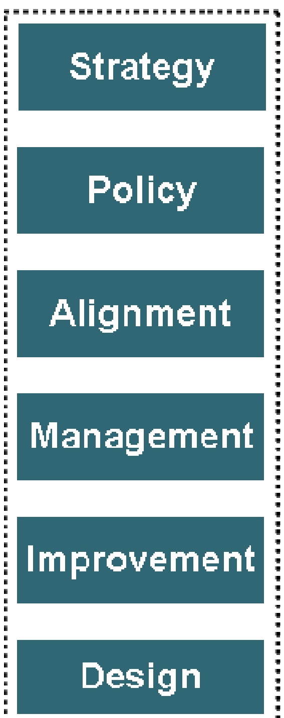

Figure 12: Governance architectural view sub-elements

Strategy Best Practices

- Adapt reverse supply chain processes to business model
- Adapt reverse supply chain processes to market developments

- Adapt reverse supply chain operations to business objectives
- Integrate returns into business model through lifecycle approach to products
- Apply business intelligence to returns process
- Reverse supply chain should be strategic, profit generating, cross-functional core business process
- Treat reverse supply chain as strategic initiative to close the loop
- Define strategies, operations and guidelines clearly
- Create returns process as customer service incentive to increase revenue
- Create differentiated service offerings to increase revenue
- Utilize returns as source of service spare parts
- Determine technical feasibility of redeploying returned products to field

Policy Best Practices

- Deploy consistent, global returns, disposition and FA policies
- Deploy a zero returns policy when appropriate

Alignment Best Practices

- Align incentives across reverse supply chain stakeholders
- Align supply base by investing time and resources to establish trust
- Align understanding of process, objective, performance expectations
- Connect returns process to customer needs and customer relationship management
- Develop a holistic end-to-end view of reverse supply chain
- Develop an integrated, standardized, cross-functional post-sales service framework

Management Best Practices

- Manage reverse supply chain to customer commitments and stated goals
- Manage policy and contract enforcement
- Manage compliance as strategic competency
- Manage trade agreements
- Manage transportation spend

- Manage installed base of products
- Manage services effectively
- Manage financial impact of reverse supply chain
- Manage returns allocation based on time value (perishability) for maximum value recovery
- Apply financial metrics and tangible cost impacts to decision rules
- Align reverse supply chain costs with sales opportunities
- Price products based on (historical) field returns information

Improvement Best Practices

- Continuously improve all stages of reverse supply chain
- Drive future improvements by transforming foundations (visibility, trade compliance, transportation contract management)
- Drive service improvements to stimulate increased customer loyalty
- Incrementally improve in executable stages
- Invest in breakthrough activities for step-function improvements

Design Best Practices

- Design products for effective returns management
- Close the loop with design - incorporate failure information into new product designs
- Consider impact of upstream design choices on reverse supply chain
- Design for environment (cooperative designs)

9.3.2. Process Best Practices Framework

The Process architectural view can be divided into sub-elements for each of the sub-processes within a returns supply chain and end-to-end sub-elements supporting the process as shown in Figure 13. The definitions for the sub-processes can be found in the Glossary. The Process best practices are categorized by each of these sub-elements.

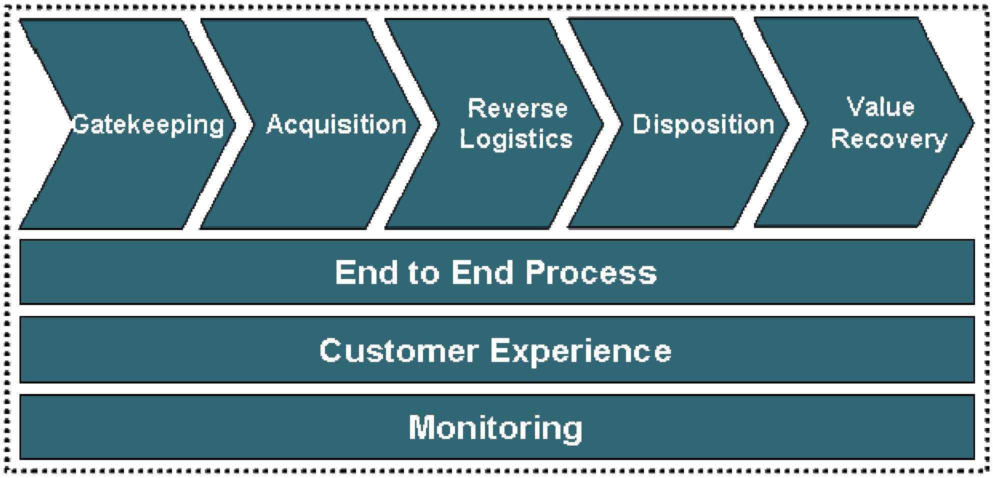

Figure 13: Process architectural view sub-elements

Gatekeeping Best Practices

- Utilize RMA authorization to manage product entry into returns stream
- Determine entry into FA/repair process based on product life-cycle phase
- Manage warranty entitlement using serial numbers and contract terms
- Avoid accepting suspected fraudulent returns
- Capture mandatory (operations, finance, other) customer information
- Conduct gatekeeping activities close to source in regional routing centers

Acquisition Best Practices

- Identify customers requiring few incentives for returning products in a timely manner
- Plan acquisition of products from customers
- Follow up with customers to recover failed products
- Manage returns acquisition process

Reverse Logistics Best Practices

- Schedule product returns in receiving
- Receive and verify accuracy of product returns
- Transfer returned products to end-processing site
- Provide pre-approved packaging and labeling solutions to customers for returns
- Utilize reusable packaging to minimize impact on environment

- Simplify, align and streamline customs process
- Clarify products early in supply chain process to facilitate import/export handling
- Maintain inventory in foreign trade zone for simplified customs and clearance
- Create straight-through processes with reverse logistics providers
- Utilize cross-docking to minimize processing delays

Disposition Best Practices

- Implement processes to disposition prior to actual receipt of returns
- Simplify product identification at receiving for easy disposition
- Disposition products based on characterization as functional (predictable demand, long life cycle) or innovative (variable demand, short life cycle)
- "Prepone" (i.e., disposition returns as early as possible)
- Decentralize preponement to minimize costly delay and minimize transportation of scrap
- Simplify disposition (sorting and processing) activities

Value Recovery Best Practices

- Recover warranty costs from suppliers
- Identify options for reprocessing, disassembling, refurbishing, remanufacturing, and recovering returns
- Postpone reprocessing to reduce holding costs for finished goods
- Utilize returns as source of service spare parts
- Identify remarketing opportunities for returns
- Consider utilizing secondary markets for remarketing

End to End Process Best Practices

- Create systematic end-to-end returns process for warranty including definition in contract, automated claims processing, financial reconciliation and analytics
- Clearly define the returns process
- Develop returns process supporting heterogeneity (high product mix) and intermittence (low spiky volume)

- Identify, prioritize, aggregate return requirements
- Identify, assess, aggregate returns resources
- Balance return related resources with return requirements
- Establish and communicate returns plans
- Integrate reverse supply chain processes
- Proactively coordinate processing and logistics steps throughout reverse supply chain
- Manage reverse product flows arising at all supply chain stages
- Avoid manual workarounds throughout process
- Pull products through reverse supply chain using web-based tools
- Identify bottlenecks and manage system constraints in reverse supply chain to increase end-to-end throughput
- Match throughputs of various stages to avoid bottlenecks
- Standardize and simplify returns process
- Manage process variation through documentation and training
- Synchronize supply of returns with demand for service products
- Maintain custom product configurations through repair operation
- Organize returns processing using cells and Lean techniques
- Close the loop through feedback to other processes

Customer Experience Best Practices

- Design hassle-free returns process
- Design customer friendly reverse supply chain process
- Follow up with customers throughout returns process
- Offer customers credit faster during returns process
- Collaborate with customers to prevent negative impact of returns on their operational and financial performance

Monitoring Best Practices

- Create a tracking process
- Monitor transportation delays (esp. international)

- Monitor customer and provider delays
- Utilize exception handling tools and processes as necessary
- Utilize alerts for event/exception management
- Utilize alerts for planning receipts and forecasting

9.3.3. Reverse Supply Chain Design Best Practices Framework

The Reverse Supply Chain Design architectural view can be divided into the 7 sub-elements shown in Figure 14. The Reverse Supply Chain Design best practices are categorized by each of these sub-elements.

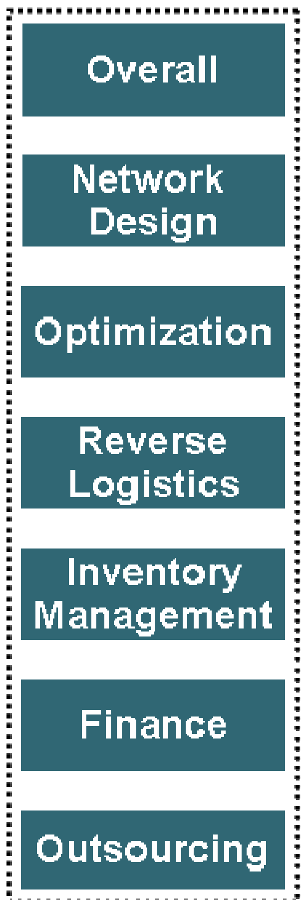

Figure 14: Reverse Supply Chain Design architectural view sub-elements

Overall Reverse Supply Chain Design Best Practices

- Create holistic reverse supply chain incorporating network design, processes, organization, policies and information systems
- Design reverse supply chain for volume scalability (via planning, integration and capacity management)
- Determine corporate position relative to efficient frontier on tradeoff curve for service level vs. cost and eliminate non-value added activities to get on the efficient frontier
- Improve reverse supply chain network to shift the efficient frontier
- Manage channels for returned products
- Plan and manage diagnosis/repair labor allocation

Network Design Best Practices

- Integrate reverse and forward supply chains while managing the structural and business differences
- Build a competitive reverse supply chain infrastructure
- Design reverse logistics network for interaction among multiple agents with different roles
- Reverse supply chain design involves tradeoffs between speed and cost efficiency
- Determine if focus for reverse SC architecture is speed (decentralized) or cost efficiency (centralized)
- Utilize responsive supply chain for products with high marginal value of time or for speed, and efficient supply chain for products with low marginal value of time or minimized cost
- Design reverse supply chain to manage regional and global customer needs
- Decide location of facilities based on available competencies and infrastructure
- Design of reverse supply chain network can utilize mixed-integer linear programming facility location models
- Exploit learning economies through assigning product families to specific FA/repair locations
- Exploit economies of scale through centralization (reduced investment) and co-location of manufacturing and repair operations
- Utilize centralized returns network for simplified acquisition of products

- Determine centralization level for sorting and testing operations in returns process
- Locate repair facilities close to receiving and disposition operations for minimized waste
- Locate distribution centers close to customers to reduce expedited air shipment costs
- Manage flow and add capacity as necessary across reverse supply chain
- Design reverse supply chain using push and pull strategies for product and information
- Determine push-pull boundary based on complexity of products (high-complexity - upstream, low-complexity - downstream)

Optimization Best Practices

- Optimize reverse supply chain based on capacity constraints at depots, warehouses, FA sites
- Can optimize reverse supply chain for few high-value parts or high-volume commodity parts
- Determine push-pull boundary based on complexity of products (high-complexity - upstream, low-complexity - downstream)
- Separate and optimize individual processes for tailored network design

Reverse Logistics (Design) Best Practices

- Design a flexible, scalable global logistics network
- Establish a global trade competency center to leverage worldwide logistics
- Exploit economies of scale through consolidation of outbound (forward) and inbound (reverse) logistics

Inventory Management Best Practices

- Determine inventory levels when designing reverse supply chain
- Reduce demand and supply uncertainty for inventory cost savings
- Apply multi-echelon inventory models and tools to inventory optimization in reverse supply chain
- Manage inventory level and forecasts within reverse supply chain

Finance Best Practices

- Invest in opportunities to move up the efficient frontier (Service Level vs. Cost)

- Synchronize financial and physical supply chains to manage reverse supply chain constraints and risks
- Plan reverse supply chain finance for unanticipated capacity risk, duties, customs fines and increases in logistics costs
- Negotiate with partners for best value (not lowest cost)

Outsourcing Best Practices

- Make outsourcing decision based on Total Cost of Ownership, operational efficiencies, revenue growth opportunities, and customer satisfaction
- Outsource reverse logistics (receiving, processing), repair (diagnosis, resolution) to third party service providers when appropriate
- Outsource warranty claim execution to third parties when appropriate
- Outsource management of service parts stocking locations to third parties
- Monitor outsourced logistics providers for performance to expectations and commitments
- Partner with third party providers that provide best value (not lowest contract cost)
- Synchronize activities, increase process visibility and control with third party outsourcing partners
- Make early decision about outsourcing repair operations or conducting them in-house

9.3.4. Organization Best Practices Framework

The Organization Design architectural view can be divided into the 3 sub-elements shown in Figure 15. The Organization best practices are categorized by each of these sub-elements.

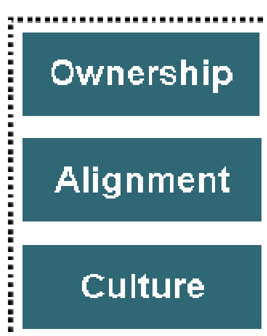

Figure 15: Organization architectural view sub-elements

Ownership Best Practices

- Empower an internal executive champion to create and oversee reverse supply chain policies and performance
- Organize reverse supply chain group with high-level oversight and accountability
- Organize returns management under single group

(Organization) Alignment Best Practices

- Align reverse supply chain organizational reporting structure
- Eliminate silos created by departmental boundaries
- Align all functional groups involved with reverse supply chain
- Create cross-functional, global alignment for efficient supply chain and minimized documentation challenges
- Integrate reverse supply chain organization with design, manufacturing, marketing and sales

Culture Best Practices

- Address cultural differences when defining policies across multiple geographies
- Ensure organizational buy-in for success of transformation initiatives

9.3.5. Enabling Technology Best Practices Framework

The Enabling Technology architectural view can be divided into the 4 sub-elements shown in Figure 16. The Enabling Technology best practices are categorized by each of these sub-elements.

Automation Best Practices

- Automate and link unrelated reverse supply chain processes
- Automate physical and information flows
- Automate and integrate supply chain processing systems and apply web-based technologies
- Automate compliance and documentation process using central data repository
- Automate trade documentation and account management
- Automate warranty processing, reporting and data analysis

- Automate early payment programs for vendors

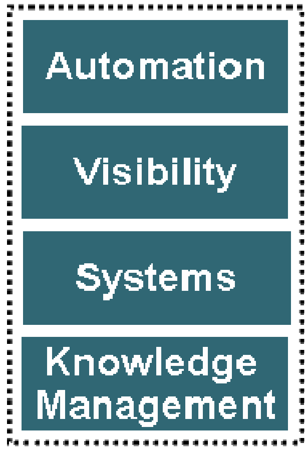

Figure 16: Enabling Technology architectural view sub-elements

Visibility Best Practices

- Create information and physical visibility throughout global reverse supply chain using technology
- Create early visibility for incoming product returns
- Create inventory visibility throughout value chain
- Apply next generation technologies like RFID for warranty claims processing
- Use regular alerts for structured notification, issue resolution and root cause analysis
- Synchronize demand, inventory and shipments across reverse supply chain for global visibility
- Deploy RFID technology for speed, accuracy and depth of information
- Utilize RFID for in-transit visibility and detailed product data tracking
- Utilize data loggers in products to determine hours and conditions of use

Systems Best Practices

- Deploy technology to achieve reverse supply chain speed at lower cost
- Invest in reverse logistics information systems providing adequate reliability and decision support
- Integrate information systems to ensure accuracy and availability for decision making
- Deploy integrated technology (e.g., RFID, WMS) to reduce labor and control inventory

- Deploy data warehouse providing internal and external visibility
- Deploy methodology for task and resolution workflow
- Deploy warranty processing systems to manage accuracy of claims and settlements

Knowledge Management Best Practices

- Capture information appropriate for business context
- Link customer and manufacturing information related to returns
- Manage customer and product knowledge captured during returns processing and share across value chain
- Manage information, availability of data and forecasts for maintaining closed loop supply chain efficiency
- Deploy decision support tools to support returns process
- Utilize cross-docking decision tools applying business rules
- Capture real-time information for improved decision support
- Link information flows to avoid info asymmetry during decision making
- Capture historical timeframe information for returns
- Utilize enhanced warranty management approaches beyond reporting
- Deploy management tools (e.g., Six Sigma) for improved reliability of operations
- Synchronize repair with contract manufacturers using technology

9.3.6. Performance Management Best Practices Framework

The Performance Management architectural view can be divided into the 3 sub-elements shown in Figure 17. The Performance Management best practices are categorized by each of these sub-elements.

Measurement Best Practices

- Establish global, corporate-wide metrics for reverse supply chain aligned with strategy and performance measurement
- Identify KPIs relevant to business model, provide incentives for employees to achieve KPIs, and measure for performance

- Align measurement criteria and incentives across enterprise
- Establish frequency of measurement for KPIs and evaluate KPIs holistically
- Provide performance monitoring dashboards and scorecards that roll up metrics from disparate sources into single aggregate view
- Systematically measure performance and outcome of process
- Analyze potential financial and strategic benefits of reverse supply chain processes
- Establish activities to maintain good performance
- Systematically analyze financial consequences of activities
- Decide returns disposition and processing based on clear, measurable, executable criteria
- Deploy performance-based contracts to reward or punish suppliers

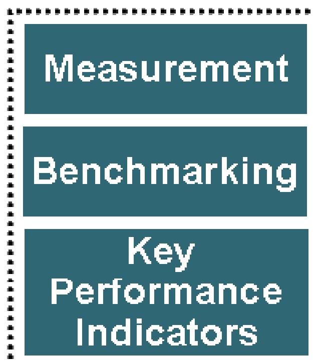

Figure 17: Performance Management architectural view sub-elements

Benchmarking Best Practices

- Benchmark against industry standards, peers and competitors
- Benchmark against peers in same industry (e.g., high-tech warranty claims processing time = 2 business days)
- Benchmark against different sectors: Best performing sectors for warranty management: industrial management, aerospace and defense, consumer goods, telecom/utilities
- Benchmark against overall best-in-class: 0.9% of annual revenue spent to support warranty claims, 1.4 business days to process claim, get 2.5% of products returned for repair during initial warranty period

Key Performance Indicators (considered Best Practice metrics)

A. Financial KPIs

- Financial impact on revenue, costs, asset turnover
- Service revenue growth
- Marginal Value of Time (MVT) as measure of clockspeed
- MVT = loss in value per unit of time spent awaiting completion of process
- Economic Value Add (EVA)
- Potential market value of recoverable items in stock support management
- Total investment in returns

B. Qualitative KPIs

- Customer satisfaction index
- Logistics benefits from returns
- Marketing benefits from returns
- Offering of extended products evaluated against measures of customer retention and customer profitability
- Disposition reasons tracking: Source of info on technical product defects and customer preferences
- Time required to develop profitable recovery processes for new products
- Warranty negotiation using bathtub curve of product failures

C. Process KPIs

Time

- Overall process cycle time
- Claim processing time
- Disposition cycle time
- Process step cycle time
- Transformation time for returned product (into usable inventory)
- Return transportation time
- Time from RMA to return receipt

- Response time to customer
- Time to resolution of issue
- Time from defect duplication to root cause
- Time from defect duplication to repair
- Time from defect detection to correction
- Time from sale to defect detection
- Daily throughput equivalency
- Throughput rate at returns center
- Throughput rate at FA site
- Delivery rate between sites

Cost

- Claim processing cost
- Disposition cost
- Disposal cost
- Logistics cost
- Operational cost throughout returns process
- Recovery cost
- Change and exception management cost
- Repair (FA) cost
- Warranty cost per product
- Total warranty cost

Asset efficiency

- FA Inventory
- Return Inventory
- Obsolete Inventory
- Total supply chain inventory
- Return inventory turns
- Technical productivity

Customer service

- # in-warranty product returns

- # warranty incidents per product
- % returns processed correctly and in-time
- Replacement order fill rate
- On-time delivery to SLA
- Perfect Order fulfillment
- FA site confirmation of problem condition ID at customer
- On-time repair and delivery against promise date
- First time resolution rate
- Warranty compliance rate

9.3.7. References for Best Practices in this Framework

The Reverse Supply Chain Best Practices were developed from public sources, standards, and existing literature on reverse logistics, warranty, repair, closed-loop supply chains, RFID and supply chain strategy. The references for these best practices are listed here.

1. Best Practices in International Logistics. Manhattan Associates and Aberdeen Group, 2006. <http://www.manh.com/library/MANH-INSIGHT_Best_Practices_ILS.pdf>.
2. Blackburn, J. D., et al. "Reverse Supply Chains for Commercial Returns." California Management Review 46.2 (2004): 6-22.
3. de Waart, D., and S. Kemper. "Five Steps to Service Supply Chain Excellence." Supply Chain Management Review 2004: 28-35.
4. Diane, A. M., and J. C. David. "The Hidden Value in Reverse Logistics." Supply Chain Management Review. July 2005.
5. Enslow, Beth. Grappling with Globalization: A Blueprint for Global Trade Management. Aberdeen Group, 2005. Aug 1, 2006. <http://www.aberdeen.com/summary/report/bvr/BVR_Globalization_BE.asp>.
6. Fleischmann, M., et al. Reverse Logistics: Capturing Value in the Extended Supply Chain. 2004.
7. Fleischmann, M., J. A. E. E. van Nunen, and B. Graeve. "Integrating Closed-Loop Supply Chains and Spare-Parts Management at IBM." Interfaces 33.6 (2003): 44-56.

8. Fleischmann, M. Reverse Logistics Network Structures and Design. Vol. Reference No. ERS-2001-52-LIS. Erasmus Research Institute of Management, 2001.
9. Guide, V. D. R., T. P. Harrison, and L. N. van Wassenhove. "The Challenge of Closed-Loop Supply Chains." Interfaces 33.6 (2003): 3-6.
10. Norek, C. D. "Returns Management: Making Order Out of Chaos." Supply Chain Management Review 2002: 34-42.
11. Rogers, D. S., and R. S. Tibben-Lembke. Going Backwards: Reverse Logistics Trends and Practices. Reverse Logistics Executive Council, 1999.
12. Shrivastava, S. Wipro Whitepaper: RFID in Returns Management in the Hi-Tech Industry. Wipro Technologies Ltd., 2005. Aug 1, 2006. <http://www.wipro.com/whitepapers/industries/manufacturing/rfid_returns_mgmt.htm>.
13. "Supply Chain Operations Reference (SCOR 8.0) Model." Supply-Chain Council. <http://www.supply-chain.org>.
14. Thrikutam, P., and S. Kumar. Infosys Whitepaper: Turning Returns Management into a Competitive Advantage in Hi-Tech Manufacturing. Infosys Technologies Ltd., 2004. Aug 1, 2006. <http://www.infosys.com/industries/electronics_hightech/white-papers/Returns_Mgmt.pdf>.
15. Trebilcock, R., Editor at Large. "Tighter Information Connections." Modern Materials Handling. 2005.
16. van Nunen, J., and R. A. Zuidwijk. "E-Enabled Closed-Loop Supply Chains." California Management Review 46.2 (2004): 40-54.
17. Vigoroso, M. W. Managing Service Chain Performance for Competitive Advantage. Aberdeen Group. 2005. <http://www.aberdeen.com/summary/report/bvr/BVR_Progistix_ServiceChainPerformance_020205_MV.asp>.
18. Vigoroso, M. W. Winning with Integrated Warranty Management. Aberdeen Group, 2006. <www.aberdeen.com/summary/report/benchmark/RA_WarrantyMgmt_MV_3181.asp>.
19. Walker, W. T. "Rethinking the Reverse Supply Chain." Supply Chain Management Review May/June 2000: 52-9.

20. White, C. D., et al. "Product Recovery with some Byte: An Overview of Management Challenges and Environmental Consequences in Reverse Manufacturing for the Computer Industry." Journal of Cleaner Production 11.4 (2003): 445-58.

9.4. Appendix 4: Reverse Supply Chain Best Practices based Diagnostic Tool

The Reverse Supply Chain Best Practices Framework can be applied to develop a diagnostic tool for measuring the company's reverse supply chain capability. The company's capability is measured in terms of maturity levels similar to those defined by the Carnegie Mellon University Software Engineering Institute's Capability Maturity Model® Integration (CMMI) framework. CMMI is a process improvement approach that provides organizations with the essential elements of effective processes. It can be used to guide process improvement across a project, a division, or an entire organization. CMMI helps integrate traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes.[63] The maturity levels defined by CMMI are:

5 – Optimizing
4 – Quantitatively Managed
3 – Defined
2 – Managed
1 – Initial

A snapshot of this diagnostic tool showing the page for the Organization architectural view is shown in Figure 18. The diagnostic tool can be adapted for use within a benchmarking study that assesses the company's capability compared to industry standards or to peers in the industry.

[63] "CMMI General Information." Software Engineering Institute (SEI) at Carnegie Mellon University. 2007.

			Rating Levels (5 = Highest, 1 = Lowest) 5 - Optimizing 4 - Quantitatively Managed 3 - Defined		
		Total Score:			
Enterprise Architecture Element	**Sub-elements**	**Best Practices**	**As-is state**	**To-be vision**	**Gap between as-is and to-be**
Organization	Ownership	Empower an internal executive champion to create and oversee reverse supply chain policies and performance			
Organization	Ownership	Organize reverse supply chain group with high-level oversight and accountability			
Organization	Ownership	Organize returns management under single group			
Organization	Alignment	Align reverse supply chain organizational reporting structure			
Organization	Alignment	Eliminate silos created by departmental boundaries			
Organization	Alignment	Align all functional groups involved with reverse supply chain			
Organization	Alignment	Create cross-functional, global alignment for efficient supply chain and minimized documentation challenges			
Organization	Alignment	Integrate reverse supply chain organization with design, manufacturing, marketing and sales			
Organization	Culture	Address cultural differences when defining policies across multiple geographies			
Organization	Culture	Ensure organizational buy-in for success of transformation initiatives			

Figure 18: Snapshot of Diagnostic Tool based on Reverse Supply Chain Best Practices Framework

9.5. Appendix 5: Decision Model for Failure Analysis Supply Chain

This appendix describes the decision model developed for analyzing Cisco's failure analysis supply chain design alternatives and recommending a design. For confidentiality reasons, proprietary information relating to sites, products, etc. has been masked, and data shown in the model is scaled where necessary.

9.5.1. Starting the modeling effort

The decision model can be used to make more data-driven, structured decisions among alternative designs or site networks. This decision model was developed to ensure that Cisco's Failure Analysis Site selection is objective, consistent across products and sites, and aligned with customer expectations relating to rapid turnaround time and visibility of FA cases throughout the FA process. It considered the challenges faced by the current Failure Analysis process, incorporates best practice decision criteria and compared Cisco's existing network of sites used for repair, manufacturing, new product introduction, etc. to recommend an improved supply chain for Global Failure Analysis.

Prior to developing the model, it is important to ensure that relevant stakeholders are included in the decision making team. This team should then identify the decision to be made, the alternative designs to be considered, and mandatory/non-mandatory decision criteria that will be used to compare the design alternatives. The team should also designate one or more members to develop the model, gather the data, make recommendations and remain involved in decision making.

9.5.2. Stakeholders involved in data gathering and decision making[64]

The decision model should be utilized by a cross-functional team of decision makers representing the stakeholder groups responsible, accountable and consulted for the decision. Each stakeholder group is expected to help the analyzing team members gather relevant data and information that is under their control or influence and needed for the decision. Input from the stakeholder groups is critical to reaching a sustainable decision with relevant buy-in for implementation. At a minimum, the following stakeholder(s) should be represented in the core team for Failure Analysis related decision making:

1. *Engineering Failure Analysis or Engineering Quality team*
2. *Manufacturing Failure Analysis or Manufacturing Quality team*
3. *Corporate Quality team*
4. *Service or Technical Support team*
5. *Returns related Logistics team*
6. *Supply Chain or Manufacturing Strategy team*
7. *Outsourced site managers*

Other stakeholder groups who can provide input to the decision should be included on an as-needed basis (e.g., Supply Chain Risk, Supplier Management, IT, Finance, Legal etc.).

[64] For completeness, the stakeholders that should be involved in a decision relating to failure analysis supply chain architecture are repeated in this section of the appendix

9.5.3. Terms and definitions used in the model

1. ***Constraints*** **-** Must-have decision criteria which all alternative designs/sites must satisfy in order to be considered within decision. Selected alternative should satisfy all constraints.
2. ***Current Baseline*** **-** Site or contract FA network design used currently.
3. ***Decision Alternatives*** **-** Alternatives (different site networks) to be compared using criteria that are important to the decision.
4. ***Decision Criteria*** **-** Factors used to make decision among alternatives. Alternatives are rated against decision criteria to determine overall desirability.
5. ***Decision Model*** **-** Framework (or quantitative model) utilized to decide among alternatives. It shows how decision alternatives compare against each other with respect to the decision criteria.
6. ***Decision Objective*** **-** Statement describing the decision to be made.
7. ***Information Infrastructure*** **-** Information that should be captured and systems to capture such information. This includes availability of customer, manufacturing, FA, repair, logistics, product, technology, supplier and financial information at the FA sites and the ability of the sites to capture return reasons, and manage performance metrics. It also considers the basic availability of enabling infrastructure technology for information capture and sharing across the supply chain. Goal is to maximize information visibility throughout supply chain.
8. ***Risk*** **-** Actual and potential risks expected when implementing alternatives.
9. ***Skills/Capability*** **-** Skills or capability required to support failure analysis. This includes the technical, business, systems, and quality capabilities of the FA sites as well as product flexibility, priority and exception handling ability and inherent product knowledge that exists at those sites. Goal is to maximize skills/capabilities (matching to product complexity).
10. ***Strategic Considerations*** **-** Important (non-quantitative) factors to be considered when making final decision.
11. ***Total Cost*** **-** Total cost incurred through the failure analysis process. This includes the product cost of returns, the cost of transportation and insurance during movement to the FA site, taxes and duties for importing the product into the country where the FA site is

located, other related logistics fees, handling and processing costs related to the return, and the standard cost charged by the FA partner for conducting failure analysis. In cases where infrastructure needs to be added, transferred or the process changed, costs relating to setup, training and operations should also be included in Total Cost. Goal is to minimize total cost.

12. ***Turnaround Time* -** End-to-end cycle time from case creation to completion of Root Cause Failure Analysis. Goal is to minimize turnaround time.

9.5.4. Structure of the model

The model includes a main summary page that provides a high-level summary of the rated alternatives against their decision criteria, a main input page that identifies the following elements, one page per decision criteria to evaluate alternatives against sub-criteria, and one or more supporting data pages to capture the data that will guide the individual ratings. The elements of the model include:

- ***Decision Objective*** to identify the desired outcome of the decision.
- ***Decision Criteria*** that would be used to rate the decision alternatives. Four major decision criteria were selected to address the primary challenges faced by the existing Failure Analysis system that aligned with customer expectations and desired stakeholder value. Turnaround time, Skills/Capabilities, Information Infrastructure and Total Cost form the criteria used for the analysis.
- ***Decision sub-criteria*** which are subsets of the higher-level decision criteria and contribute to the rating for decision alternatives. These break out the high-level criteria into more granular criteria for which data is available.
- ***Risk Mitigation:*** In addition to 4 major decision criteria, the decision model also captures risk related to the site network alternatives and identifies if risk mitigation is possible. Risk related sub-factors are based on Cisco's methodology for supply chain risk assessment. In general, decision alternatives for which risk cannot be mitigated should be removed from the decision. However, if all alternatives have some risk that cannot be mitigated, further investigation will be necessary to identify the lowest acceptable-risk alternative.

- ***Strategic Considerations:*** The decision framework also lists some strategic factors that should be considered in the final decision but are not quantified in the model.
- ***Importance and Ratings:*** The importance of each of the decision criteria is based on a 1 to 10 scale (10 being most important). Importance for the criteria should be determined collaboratively by a cross-functional core team of decision makers from across the company. Ratings for each of the major criteria are also on a 1 to 10 scale (10 being most important). The best alternative based on that criterion is rated 10 and all other alternatives rated relative to the best alternative.

9.5.5. Modeling assumptions and results

In every model, there are inherent assumptions that need to be considered when evaluating the results or recommendations. For example, in large, high-tech organizations like Cisco, information obtained from multiple sources may not always match due to different assumptions made when capturing the data. In some cases, data may be missing due to systemic features or lack of importance afforded to such data historically. In such cases, subjective evaluations may be necessary or the analyst might use their "best judgment" to use "similar" data to fill gaps.
In other cases, variance in the data may not be captured if historical averages are used to evaluate the alternatives. In this model, costs are captured in absolute terms (based on estimated averages) with no adjustments made for time value of money. While this provides a reasonable estimate for short-term decisions, true long-term decisions should consider the net present value of return on investment for the design alternatives. In addition, various uncertainties that cannot be easily captured in the model should also be noted, including:

a) Failure Analysis case volumes and product return volumes, from specific regions
b) Operational (variable, fixed) and setup costs and impact of foreign exchange rates in global networks
c) Risk scoring methodology and related risk data
d) Service Level Agreements with logistics and contract FA providers (relating to the time, cost, information, capabilities provided)
e) Strategic objectives and decisions of the company (e.g., opening new manufacturing sites)

f) Supply chain structure (multi-level using return depots, in-region consolidation sites, FA/manufacturing sites)
g) Technology, business and support capabilities of various sites relative to other sites
h) Time period for which data is gathered

Using a summary of ratings, decision alternatives were evaluated against selected decision criteria and importance levels. This summary indicated that failure analysis be conducted in the Alternative 1 network. A snapshot of this summary is shown in Figure 19 below. This design alternative would reduce turnaround time, improve skills and capabilities, improve information infrastructure and reduce overall cost better than other alternatives, relative to the current (baseline) FA network. However, it should be noted that the overall score for this alternative was only slightly better than that for Alternative 3 (and worse than Alternative 5 for some criteria). Nevertheless, given the constraints and the importance of each of the decision criteria, Alternative 1 performed best on an overall basis compared to the others.

In most decisions, alternatives for which risk cannot be mitigated should be eliminated. However, in this analysis, all decision alternatives had some risk associated with them which cannot be mitigated. This is primarily due to lack of data around the sites within each Alternative network design. Further investigation and data may reveal that risk mitigation may be possible for one or more alternatives. As a result, the final decision should be re-evaluated in the context of identifiable lower risk alternatives. The FA supply chain design recommendation from the decision model should be socialized among key stakeholders including those responsible for higher-level business strategies and implemented as part of a change roadmap for propelling the Global Failure Analysis system into a best-in-class position.

SUPPLY CHAIN DESIGN FOR CLOSED LOOP CORRECTIVE ACTION AND GLOBAL FAILURE ANALYSIS

12/13/2006

CLICK TO START

HELP!

Decision Objective

Optimize Failure Analysis Site Selection for Cisco (by selecting FA sites that will improve upon existing network)

DECISION SUPPORT TOOL - RESULTS

Decision Criteria	Importance	Current Baseline *Baseline Name*	Alternative 1 *Alternative 1 Name*	Alternative 2 *Alternative 2 Name*	Alternative 3 *Alternative 3 Name*	Alternative 4 *Alternative 4 Name*	Alternative 5 *Alternative 5 Name*	Comments	Customer/Cisco focused criteria
"Must Have" Criteria (Constraints) Met?		Y	Y	Y	Y	Y	Y		Cisco
Turnaround Time	Hidden	9.63	9.88	9.54	9.78	8.44	10.00		Customer
Skills / Capability	Hidden	8.82	9.70	8.59	9.70	9.86	10.00		Cisco
Information Infrastructure	Hidden	9.91	10.00	9.73	10.00	6.36	8.72		Customer
Total Cost	Hidden	9.92	9.96	9.92	9.82	9.75	10.00		Cisco
Total Weighted Score		*285.80*	*296.22*	*281.70*	*294.69*	*253.19*	*289.74*		
Ranking (highest score = 1)		*4*	*1*	*5*	*2*	*6*	*3*		
Overall Risk Impact (out of 100; lower better)		40	42	41	42	37	42		
Risk Mitigation Possible (Y/N)		N	N	N	N	N	N	*All options have some risk mitigation issues based "unknown" sites for some product families. Should evaluate severity and detailed risk mitigation plans*	

Final Decision	
	Decision: Based on the total score and risks involved, we will: - Recommend aligning FA sites with Alternative 1 - Evaluate severity of risk for selected network and implement risk mitigation plans for affected sites. - Consider additional cost of settting up FA related infrastructure at Alternative 1 network sites prior to finalizing the decision.

Figure 19: Summary page from Decision Model for Failure Analysis supply network selection

9.6. Appendix 6: Research Methodology

The research presented in this thesis was conducted during a 6.5 month internship at Cisco Systems, Inc. in San Jose, California, U.S.A. This internship was carried out under the guidance of the project supervisor and MIT advisors using a 4 phased approach as shown in Figure 20.

1. ***Understand As-Is:*** This phase involved interviewing some of the stakeholders involved in the failure analysis system to understand the current state of the system and the broader closed loop corrective action initiative. Existing policies and process documents were reviewed to gain a better understanding of the intent and evolution of the failure analysis processes. In addition, visits to a returns depot and a contract failure analysis site provided an overview of the way the processes were actually being used.

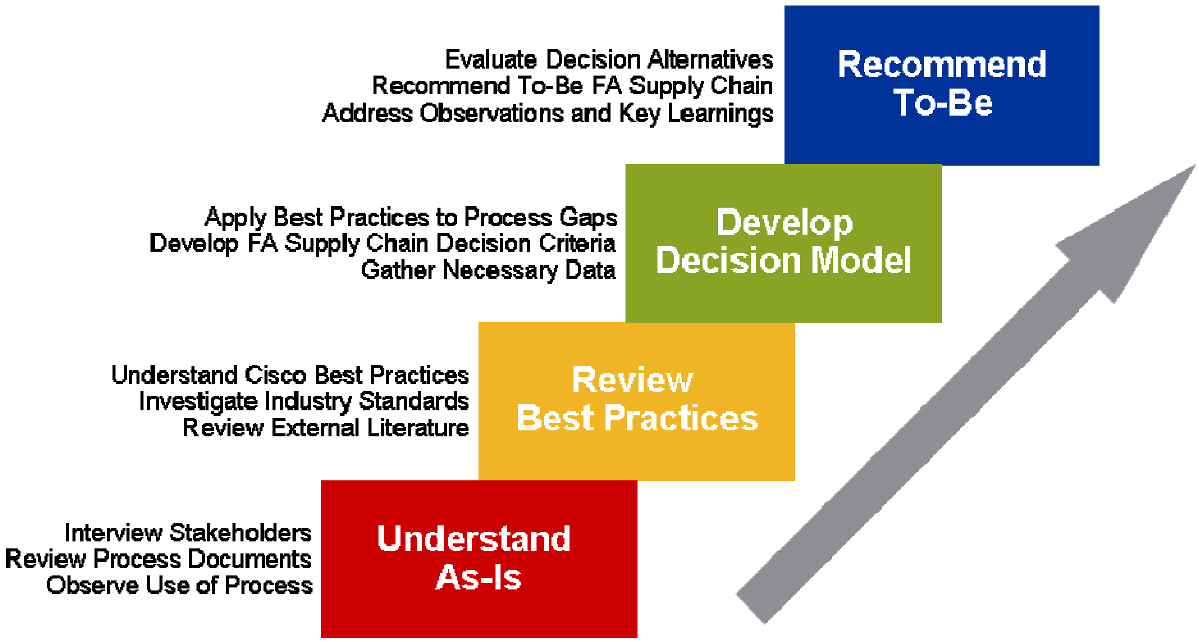

Figure 20: Research was carried out in four major phases

2. ***Review Best Practices:*** This phase of the internship project involved gaining an understanding of best practices within Cisco's virtual enterprise (including at outsourced-partners). In addition, industry standards relating to quality systems and supply chain processes were reviewed. An extensive literature review provided a broad understanding of challenges and best practices used to overcome those challenges within the context of quality, failure analysis, closed-loop corrective action, warranty management, supply chain design, reverse supply chains and product returns management. This review of best practices was used in conjunction with the understanding of as-is challenges to develop the Reverse Supply Chain Architecture presented in section 4.3 and the Reverse Supply Chain Best Practices Framework presented in section 4.4.

3. ***Develop Decision Model:*** This phase of the internship involved applying the best practices to process gaps identified from the first two phases and develop failure analysis supply chain decision criteria that would allow a team to decide among alternative supply chain designs. Data relevant to rating the designs according to the decision criteria was also gathered and the model was built to present and document the decision objective, criteria and data. This was a challenging phase of the internship, for a number of reasons. First, few decision modeling tools had been used within the organizations that I interacted

with. Secondly, data existed within different systems and a number of disparate functional groups had access to this data. Finally, gaining an understanding of the strategic decisions and the level of information available involved building working level relationships with key individuals. However, through the support and help from a number of Cisco stakeholders, this data was collected and synthesized for incorporation into the decision model.

4. ***Recommend To-Be:*** The final phase of the internship involved evaluating specific decision alternatives (alternative networks of contract sites that could be used for failure analysis), recommending the characteristics of the to-be failure analysis supply chain, and presenting the observations, key learnings and recommendations based on my involvement in the Cisco initiative. These recommendations were based on an outsider's perspective of the inner workings within the Cisco enterprise and represented my synthesis of the projects and research conducted in the field of failure analysis supply chain design.