PRODUCT-LEVEL BILL OF MATERIAL DEVELOPMENT
METHODOLOGY: PROCESS IMPLEMENTATION

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ABSTRACT

Cisco Systems maintains its leading position in the IP network equipment market through continual innovation and release of new products. In order to manage these new product introductions, the Product Operations group enables the development engine by standardizing and refining operations processes. The Bill of Materials Development Methodology (BOM DM) is a new process created to reduce BOM structuring errors and lead to an improved fulfillment experience for Cisco customers. In keeping with the Six Sigma philosophy, the BOM DM implementation team used the Define-Measure-Analyze-Implement-Control (DMAIC) approach to manage this process but struggled to find the supporting data to appropriately measure critical process parameters or quantify the impact of the solution. After re-evaluation, the approach was modified to maintain the Six Sigma mindset but abandon much of the rigor of DMAIC such that the implementation could be completed within the required timeframe and available resources. This required a new process improvement strategy that would educate the New Product Introduction (NPI) teams on the downstream consequences of their actions so that they would buy in to the need for a standardized best practice. The BOM DM was incorporated into the product development standards and each functional group was given the option to adopt. Six months later the project was reviewed to understand its effect on the company.

This thesis serves as a case study of the issues faced on many DMAIC implementations in the real world that experience less than perfect execution. Though sacrificing the confidence that is supported by statistically significant measurement and analysis, the revised approach utilized for the BOM DM implementation leveraged two of Cisco’s prized endowments: speed and a creative entrepreneurial spirit. The goal of this thesis is to uncover the tradeoffs of such a compromise and empower managers to decide how best to engage in future process improvements.

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I have to start by saying that Cisco Systems is a stellar company and critical partner to the Leaders for Global Operations (LGO) community. Cisco is the poster child of the successful American company, which in 20 short years grew from an idea in the mind of two graduate students to the most valuable company in the world. Its achievements are a credit to the intelligence, drive, and creative spirit of the individuals employed there.

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Any contribution that this thesis provides to the success of future process improvement managers will by largely due to the wisdom and experience imparted by my two advisors Sara Beckman and Chris Magee. Through her professional, academic, and consulting experience Sara has amassed a wealth of knowledge in management science and her guidance was always as inspirational as it was implementable. Chris provided the grounding that I needed to keep this thesis objective and well supported.

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Introduction

The problem statement

Many companies today struggle to cope with the tension that exists between innovation and execution. Organizations find that the qualities that foster innovation often are not the same as those which drive operational excellence and find it difficult to encourage the appropriate balance. Cisco Systems is no exception. Unprecedented inorganic growth, an action-driven culture, and focus on speed to market have helped propel Cisco to the status of the world’s most valued company in the year 2000. Simultaneously, managers at Cisco strive to enable execution effectiveness through the efficiencies of standardized and routine processes. The Product Operations group sits at the center of this dilemma as it functions to rapidly bring new products to market and to do so with maximum efficiency. Examining how Cisco’s fast paced change-oriented culture makes it difficult to fully adopt business process management theories that require methodical data-driven decision-making presents a practical example of this challenge.

Cisco has been quite successful at acquiring companies and integrating them into “the Cisco way”. Managers at Cisco are able to achieve this by both ensuring that the company is a cultural fit before it is acquired and then allowing it to continue functioning in the way that has enabled its past success. While this technique is great for “successfully” integrating companies, it creates an organization in which many independently functioning business units are using unique processes to develop new products. As these products reach the end of the development phase and enter the supply chain they all come to the central Product Operations group. The challenge for this group is to take products developed in a non-standard way and integrate them with a highly efficient and standardized supply chain.

The solution for Product Operations is to survey the processes employed by the business units, identify the best practices, and implement standard procedures that all business units are expected to follow. As will be discussed further in Chapter 3, the product operations group identified the lack of standardization in bill of materials development methodologies as an issue that needs to be addressed.

The Purpose of the Study

This study examines applications of management theory – specifically, theory derived from quality management and now embodied in Six Sigma – in the real world. Too often companies become reliant on certain solution methodologies as the de facto standard without considering where and when that solution is most suitably applied or how it might best be adapted to a particular situation. This can lead to unsuccessful

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implementations, resource erosion, as well as loss of faith in the value of the theory and the methodology. By re-examining the theory and a case study example of a less than perfect process management initiative, key learnings can be extracted that are aimed to improve the success rate for future process management projects.

Specifically, this study examines common difficulties with DMAIC implementations. Since the late 1990s Six Sigma has permeated the business world and given companies a unique set of tools to help them achieve operational efficiency. DMAIC, a methodology for Six Sigma implementation projects, embodies a set of rules that if not followed precisely, will render the project ineffective and much of the benefit may be lost. For certain companies, cultures, and even projects, the tenets of DMAIC may even contradict the underlying values, thus it is not a cure all solution. The goal of this study is empower managers at Cisco and other companies to use DMAIC most effectively by understanding when and how it should be followed.

**Research Methodology**

This study will compare real world implementations to theory and literature on the topic. The main focus will be on a recent DMAIC project called the Bill of Materials Development Methodology (BOM DM). By comparing what was actually done with what the theory describes it is easy to see where we can often go wrong.

Interviews and literature searches provide examples of projects in other settings that experience DMAIC-related implementation issues. In addition, this study will compare articles that criticize the usefulness of Six Sigma with those who claim that the tools are only limited by the effectiveness of the project managers. By examining these ideas and others about alternatives to DMAIC and when they should be employed, a collection of recommendations will be provided for future process management projects.

**Thesis outline**

This report will begin by providing background on Cisco and Six Sigma/DMAIC. The first chapter will discuss quality and process management theory as well as some of the attitudes and challenges of implementing these theories. The next chapter will present the case study of the BOM DM. The background, including Phase I of the project, will be presented as well as the findings at the start of Phase II that indicated the project was not on track for a successful DMAIC implementation. The next chapter will present the ensuing investigation and resulting project redirection. The chapter will describe how given the time and resource constraints, the team decided to pursue a less stringent approach. The new approach was based on inspiring guidelines rather than forcing a statistically supported change. Finally the results of the case study will be presented and a post-mortem analysis provided on the implementation approach success and the BOM DM's impact on the business. Lastly, the conclusions from the BOM DM project will be given and the report will finish with the recommendations for future process control project managers, which use the outcome of the BOM DM project to indicate why it is important to follow the theory.
The setup

Organizational overview

Overview of Cisco

Cisco Systems was founded in 1984 by Len Bosack, Sandy Lerner, and Richard Troiano. The founders recognized the value of IP's open architecture as a standardized platform on which the internet could grow. The company began by developing routers to run on the Internet Protocol (IP) during the late 1980s. The company grew quickly and went public in 1990 with reported revenue of $70 million. Throughout the 1990s the company grew inorganically through enormous acquisitions such as StrataCom for $4 billion in 1996 and Cerent Corp. for $7 billion in 1999. Cisco was enviably prolific through the dotcom boom and at its height in March of 2000, with an astounding market capitalization of $500 billion, Cisco became the most valuable company in the world (Lester, 2009). Cisco weathered the ensuing dotcom bust by pushing new technologies into the market that would drive the demand for their routers and switches, such as Voice Over IP (VOIP). Through the early 2000s Cisco maintained profits just under $20 billion and its mergers and acquisitions engine continued to run strong as seen in below in Figure 1.

The nature of Cisco’s growth through acquisition, 133 acquisitions to date and counting, has had several interesting side effects on the organization: it has created a culture of innovation with a “start-up” feel and it has created incredible complexity. Today Cisco is made up of 54 business units managing 3000 orders per day for its over 23,000 Product IDs (PIDs) (Lester, 2009). Given this sheer volume of business, Cisco must make a significant investment to control the processes that manage these transactions. Surprisingly, Cisco has managed to do so while nurturing a free and entrepreneurial culture. It stands as one of the great innovation companies of our age and this culture is closely guarded. In order to stay ahead in a fast paced
market, Cisco’s actions must be quick and deliberate and in order to achieve that the employees must be empowered to make action driven decisions. One way Cisco achieves this is by employing a highly collaborative work style. Abandoning the command and control work style of the past, Cisco has leveraged the company culture to achieve operational excellence and furthermore, to continually push new technologies to the market. Cisco enables this collaborative environment through extensive use of its own products such as WebEx and TelePresence.

This is part of a larger business strategy to capture markets adjacent to the traditional core routing and switching markets. The goal is to capture the value of products that leverage the IP infrastructure of Cisco’s core products and simultaneously promote further demand for even better infrastructure. Telepresence is a prime example. While Telepresence has revolutionized video conferencing, it requires astronomical bandwidth to support. As companies buy more Telepresence they also upgrade their networks. With the recent release of consumer Telepresence service providers such as AT&T and Verizon are upgrading their infrastructure, bringing us closer and closer to that 56-exabyte projection. Cisco has identified 30-50 such market adjacencies to pursue including smart grid, flip video, and physical securities. While this strategy generates new revenue streams it stretches the competencies of the organization. As the company’s product portfolio creeps, supply chain and operational complexity rain down into many parts of the company.

Customer Value Chain Management

In order to bring to production the steady stream of products developed by the 54 business units at Cisco, the Customer Value Chain Management group (CVCM) was created. This 8,000-employee group is a central function that collaborates across all of Cisco and with external partners to plan, design, manufacture, deliver, and manage customer orders, and ensure the quality of Cisco’s products and solutions. CVCM recently evolved out of the Global Supply Chain Management group when the organization broadened its focus to manage the total customer experience (Cisco, 2009).

![Customer Value Chain Management Functions](Image)
Product Operations

The Product Operations group collaborates across (CVCM) to transform innovation into robust products and create agile supply chains that deliver value across the product lifecycle. Product Operations is also charged with scaling up Cisco’s capabilities to be increasingly productive. The focus is on building an organization that is global, aligned, capable, and adaptive.

Global Engineering Operations

In keeping with this directive, Product Operations manages a group called Global Engineering and Operations (GEO), which is constantly identifying gaps in the approved processes employed throughout Cisco Product Development Methodology (CPDM) and defining the processes to fill those gaps. The charter of this group is to create value through operations excellence. One way of achieving this is by managing processes to enable the company to achieve timing and quality.

To achieve operational excellence, the GEO group employs different operations management theories. In order to understand an organization’s ability to employ these theories, the Software Engineering Institute at Carnegie Mellon University created a model of the evolution of an organization’s understanding of process known as the Capability Maturity Model (CMM). The model describes five stages (Initial, Repeatable, Defined, Managed, Optimized) that companies go through as they mature. The assumption of
this model is that immature companies do not perform consistently, while mature companies effectively and consistently create products and services (Harmon, 2003).

In order for organizations to reach maturity, they must constantly refine their corporate goals in accordance with the changing business environment. These corporate goals define a strategy and in order for that strategy to be implemented the business processes must be altered to reflect the inherent values. These new business processes have an effect on the course of business and the further changes the business environment. Eventually, new strategies are needed and the cycle begins again (Harmon, 2003). Figure 5 depicts the cyclic nature of business process change.

This is played out through the multitude of operations management theories, such as Lean Manufacturing, Six Sigma, and TQM, that honor the pursuit of quality, and that have made it a commonly known fact that process standardization is critical to achieve operational excellence (Ramakumar, 2004). Furthermore, Ramakumar states that “Six Sigma is becoming the de facto standard as a systematic methodology to enforce process standardization with the ultimate goal of producing near defect-free products and services profitably.” This is a common sentiment in the business world today, as evidenced by the fact that Six Sigma has been embraced in some way by 82 of the 100 largest companies in America (Hindo, 2007).
Figure 6 depicts a common scenario within the Global Engineering Operations team where a new process standardization project was chosen to fill in a gap within CPDM, in this case the BOM Development Methodology. It is this mental model that motivates such projects. DMAIC remains the preferred vehicle for carrying out the process standardization projects and spreading the gospel of Six Sigma across the organization. While successful companies understand the theoretical value of standard work in achieving process excellence, in the real world there are always tradeoffs. For example, the choice of which project to pursue first and how much to invest in each, is critical to creating a positive impact from such programs. As this paper will uncover, an unguided march toward this modus operandi will not necessarily yield desirable results.

Overview of Management Theory

Six Sigma

Six Sigma is a process management strategy developed by Motorola in the mid 1980s by engineer Bill Smith as a new method to control the quality of manufacturing operations. Building on Total Quality Management (TQM), Six Sigma focuses on removing defects and variability from process outputs. The name comes from the Greek letter, σ, which represents the standard deviation. Six Sigma states that the mean value of a measured process output should lie six standard deviations (6σ) from the upper and lower control limits. For example, if the oven temperature on a specific cure cycle was measured each time and recorded over many cures, this data set should yield a mean which is six standard deviations above from the minimum required temperature and six standard deviations below the maximum required temperature. Such a process would be said to be within specification and under control. The six sigma approach advises managers to measure and analyze the appropriate process outputs, then appropriately modify the process to create outputs that fall within the desired limits. Processes that can achieve this meet the acceptable quality standard with 3.4 defects per million (Harry, 1998).

Another way to explain this is to consider three different processes for curing carbon fiber composite parts. The process output, oven temperature in degrees F, is recorded as each process is run twenty times.
The upper specification limit is 360 deg F and the lower specification limit is 340, ie the acceptable process parameters are 350 +/- 10 degrees F. The first process, shown in Figure 7, is in spec because all observations meet the specification requirements. However, given that the average is 351 and the standard deviation is 4, this process is not in control because control limits (+/-6σ) are outside the spec limits. In this case the upper control limit is 375 and the lower is 327 degrees F. The second process is out of spec and out of control because neither the actual recordings nor the control limits fall within the spec limits as seen in Figure 8. Finally, the third process is both within spec and under control because all observations and control limits fall within the spec limits as seen in Figure 9.

![Process 1](image)

Figure 7 – Six Sigma process control chart for carbon fiber curing Process 1

![Process 2](image)

Figure 8 – Six Sigma process control chart for carbon fiber curing Process 2
DMAIC

Six Sigma defines two methodologies for implementing solutions. Both are framed by Deming’s Plan-Do-Check-Act cycle for problem solving. DMADV, which is an acronym for Define, Measure, Analyze, Design, and Validate, is designed for creating new products or process definitions. DMAIC, which is an acronym for Define, Measure, Analyze, Improve, and Control, is designed for improving existing processes. DMAIC is by far the more common of the two since most Six Sigma projects are aimed towards improving a process which currently causing concern.

Since Six Sigma demands such tight control of process outputs, the process inputs must be controlled as tightly if not more. This leaves almost no room for on-the-fly creativity or innovation from those who perform the process during the daily business activities. Innovation is still welcomed but only through the proper continuous improvement channels. Organizations that support indirect engineering staff do well at differentiating the task of performing the process from the task of improving it.

Project Selection

DMAIC creates a guideline to help managers identify and manage the critical-to-quality (CTQ) characteristics of a process. In order to do so, data is required to identify, measure, forecast future values, monitor, and analyze the CTQs. Dedication to these rigorous analytics is required from the team in order to use DMAIC as it is intended. Though it can be argued that collecting this type of data is always possible, it is not always desirable, since sometimes the solution can cost more than the problem. Sometimes, even with the necessary support, it is easy to misread the data, gather the wrong data, or make specious conclusions from the data. Depending on the dynamics of the organization, some are well-equipped to handle these implementations while others are not. Thus, selecting appropriate DMAIC projects is critical to the success
of the initiative. Furthermore, projects that are most suitable for DMAIC include some or all of the following characteristics (Banelas et al., 2006):

- Customer impact
- Financial impact
- Top management commitment
- Feasible and measureable
- Learning and growing
- Connected to the business strategy and core competency

In order to successfully utilize Six Sigma and the DMAIC approach to improve a process output the process must have certain measurable characteristics. Primarily, the cost of the problem and the cost of the solution must be measurable. Since the bottom line of Six Sigma is to increase profitability through high quality process outputs, all projects must be validated with a bottom line cost/benefit business case analysis.

Mark Goldstein identifies project selection as one of 13 critical success factors of Six Sigma programs. He argues that the ability to rationalize the business case for any project is so important that a finance person should be brought into the implementation team (Goldstein, 2001). Within this, attention must be paid to the rate of return and repayment period without neglecting the magnitude of return when comparing projects. The onus is on the team that selects the project to prove that there is sufficient value in the solution to warrant the solution approach.

One way to achieve positive results from the initiative is a top-down Six Sigma project selection approach. This assures the necessary management support and leads to projects that are better aligned with the company's strategic vision. While lower levels must be involved in order to identify opportunities, top-down decision-making helps combat the pursuit of pet projects (Banuelas et al., 2006).

The challenge

The challenge to project managers is to better implement DMAIC theory in the chaos of the real world. In order to meet this challenge the following questions must be answered.

- How do project managers identify the degree to which a process improvement initiative lends itself to a DMAIC strategy given the limitations of the organization they support?
- How do project managers modify the implementation strategy to make the methodology more suitable to real world limitations?

The BOM DM project serves as a case study for how Cisco makes these decisions.
The Case Study: BOM DM project

Project Motivation

While it is difficult to place a dollar value on customer satisfaction, it is nonetheless identified as a high priority for Cisco. In fact, Cisco employee badges were changed in the spring of 2009 to include a commitment to customer focus. Furthermore, Cisco has invested significant effort in surveying customers to understand their needs and the company’s success in meeting them. To this end, the company culture readily supports customer-focused improvements. This is both good and bad because while all projects that improve customer satisfaction are welcomed, some have stronger business cases than others and should be considered first.

In early 2008, the Product Operations group began to receive emails and phone calls from a customer who was having difficulty tracking its inventory of a new Cisco product. They complained that they had at least three different Cisco products, all with the same part name “.800 Chassis” and they could not tell which was which in their inventory system. Since it required strict revision control on the product, this high profile customer, a leader in the phone and Internet service provider business, had been told to track its Cisco inventory using the Top Assembly Number (TAN) for the products (PIDs). In Cisco Bill Of Materials (BOM) language, the PID represents the highest-level part name, which is typically defined by the sales organization and used for customer ordering. The product engineers define the BOM below the PID by attaching TANs to it.

As shown in Figure 10, the BOM for this PID had been structured such that this product’s power supply was structured under the TAN. This BOM structure is depicted on the left of Figure 10 and shows that the TAN (.800 Chassis) has a power supply (.AC Pwr Supply) structured under it. Note that the number of periods (.) preceding the part name indicates the level of indentation in the BOM. This BOM has another TAN (.Pwr Expand Option) to replace the AC power supply with a DC Power Supply (.DC Pwr Supply). Under this structure the customer could order three different configurations (Chassis with AC, Chassis with DC, Spare Chassis) and all three appear as the same part in the customer’s inventory control system because they would all be received under the same TAN (.800 Chassis).

![Figure 10 - Alternate BOM configurations](image-url)
The root cause investigation uncovered that the BOM had not been properly aligned to the customer's needs. An alternative BOM structure as shown on the right in Figure 10 would have allowed the customer to order a different TAN for each configuration and enabled TAN inventory tracking.

Further investigation into this issue revealed that disparate pieces of information about the customer’s needs, the supply chain, and laws and regulations from different countries could have a dramatic impact on the BOM. As the range of Cisco’s product offerings increases, so does the complexity of BOMs and supply chains. Given Cisco’s strategic decision to pursue adjacent markets, these types of problems are likely to become more common in the future. Moreover, each business unit (BU) at Cisco has its own way of accommodating these factors and as new acquisitions are made, the number of unique methods for BOM generation and maintenance increases as well.

Consequently, there was no consistent way to manage BOM development and ensure that product-specific factors were being considered for their impact on the BOM structure. Thus, BOM development was identified as a gap in the approved processes used to govern the Cisco Product Development Methodology (CPDM), a collection of standards for new product introductions. As shown Figure 11 CPDM defines the high level processes and the Electronic Document Control System (EDCS) houses the fine-grained detail of many Cisco processes. However, the identified “gap” is the bridge linking the two that guides employees to the appropriate information at the appropriate time. An initiative to standardize a BOM development process was conceived to create this bridge and span the gap.

![Figure 11 - The BOM DM fills the gap between CPDM and EDCS](image)

**Background on the project**

The Product Operations group decided to create and roll out a formal process across the company, which would standardize BOM development and share best practices and lessons learned. Ryan Lester, a Leaders for Global Operations fellow from MIT, was brought in as an intern to create this process.

Ryan and the project team discovered that since many disparate pieces of information are needed to understand how a BOM must be structured, it is fairly common that the BOM needs to be restructured when
some new criteria are brought to light during new product introduction. The time needed to restructure the BOM causes delays to the product release and budget over-runs. Even worse, sometimes, as described above, these pieces of information are not discovered until the customer is already holding the product.

Therefore, the team created a guideline called the BOM DM to aid product engineers in aligning BOMs to create the optimum structure. The BOM DM was designed to reduce issues by establishing a disciplined process to follow when creating a BOM, which helps engineers to collect pertinent and available information and use it to structure the BOM appropriately.

One important note is that while the BOM DM fills the identified process gap in CPDM it is not a panacea for eliminating BOM structuring errors. As described in Section 3.1 of (Lester, 2009), Phase I of the project focused on identifying the problems that commonly arise during BOM development and how product complexity compounds these issues. This methodology, comprised of a collection of best practices, provides a foundation of rules and data collection upon which a more complete solution can be built. For example, the Product Operations group has been considering purchasing Agile, a product lifecycle management software solution made by Oracle. One of the functions of this tool would be to auto-generate bills of materials by selecting the appropriate BOM structure for that product. In the future if this or a similar product is purchased, the BOM DM will serve as a useful set of rules with which to program this tool.

The Bill of Materials Development Methodology is designed as a framework to assist engineers in dealing with complex structures. As a part of CPDM, it was created following the standard approach to new process development. When implementing new process management initiatives, such as the BOM DM, Cisco's business process management policy encourages the use of DMAIC. According to the Operations, Processes, and Systems (OPS) organization “DMAIC is the methodology Cisco has adopted for managing, improving and redesigning business processes.” The OPS website hosts a multitude of publications to assist project managers in understanding and using DMAIC, the Project Life Cycle (PLC) framework, and the Cisco Change Roadmap (CCR) (as seen in Appendix A). Accordingly, the DMAIC methodology was employed to carry out the BOM DM project.

Define, Measure, Analyze

The first phase of a DMAIC implementation is to “Define” the initiative by identifying a business opportunity and creating a clear problem statement to articulate it. In the BOM DM project, two main objectives were achieved during the define phase: Business Identification and Concept (Lester, 2009).

The Business Identification consisted of researching the background and foundation for the project. By examining policies, industry publications, stakeholders, and the current state of business, the following problem statement was identified: Inadequate BOM structure leads to product launch delays, increased product support costs, and lower customer satisfaction (Lester, 2009). The “Concept” consisted of refining
the scope of this project to develop a research timeline including tasks, deliverables, methodology, and the exact data collect required (Lester, 2009).

The second phase of DMAIC is to “Measure” the items that can have an effect on the problem statement. On this project, the technique for measuring such a large issue was to examine a set of representative organizations and extrapolate the results for the entire company. The data gathered from these groups was also benchmarked against industry standards (Lester, 2009).

![Business groups researched by the Phase I project team](image1)

The third phase of DMAIC is to “Analyze” the measured data. For the representative groups, the data about the process that was gathered through surveys and templates was organized into an Ishikawa (fishbone) diagram and a RACI (Responsible-Accountable-Consulted-Informed) diagram. The Ishikawa diagram visualizes the data in an arrangement that highlights the root causes of the issue. This project focused on the Process factors shown in Figure 13. The RACI diagram facilitates the identification of the key stakeholders. It also helps highlight responsibility gaps in the process (Lester, 2009).

![Ishikawa diagram from project Phase I](image2)

**Phase II Handoff**

Phase I culminated with the development of a BOM DM process map (as seen in Appendix B) and accompanying document, which accurately details the methodology. At this point the project was handed off to the Phase II team. The challenge for Phase II was to use the process definition to complete remaining DMAIC steps: Improve and Control.
Project Re-evaluation

Phase I review

In order to change the course of business it is important to have a solid case to justify the change. In other words, the change must be presented as the best cure for a pre-existing pain point. This must be clearly articulated at the onset of the implementation. Often times the pain that the implementation cures is not felt by all the stakeholders affected by the change. For these individuals it is even more important to have a clear justification for this implementation. Upon re-evaluation of the BOM DM project, several issues were identified which impeded the implementation.

Lack of supporting business case

The first recognized obstacle was the incomplete analysis of the problem, specifically regarding an understanding of how often the problem occurs and how much it is costing Cisco. Recall that one of the characteristics that makes a project a good candidate for a DMAIC implementation is that it has a clear financial benefit (Goldstein, 2001). In order to get buy-in for such strict process control it is important to have a strong defense as to why a change is necessary.

Up until that point, no data had been collected and thus no analysis had been created to truly understand the financial impact of this project. This data is needed to calculate the return on investment and without this data the business case is weak. Therefore, in addition to a weak project defense, key aspects of the implementation regarding the aggressiveness and scope of the rollout could not be determined.

No measurable CTQs identified

The second obstacle to this implementation revolves around process parameters. The Six Sigma methodology creates a clear distinction between “Critical to Customers” factors (CTCs) and “Critical to Quality” factors (CTQs). CTCs are the properties of a product that meets the customer’s expectations while CTQs are the crucial properties of a process that will yield such a product. Thus CTQs are internal process parameters. During the Measure phase of DMAIC, CTQs are to be identified and measured. By analyzing the actual process parameter outputs with Six Sigma statistical tools, each CTQ can be defined as “in control” or not. A valid Six Sigma solution will create process refinement that brings all CTQs within the accepted boundaries.

Up to this point, no measurable CTQs had been identified. Though a new process had been defined, the parameters of the process had not been identified as critical or not. Furthermore, no boundaries had been created to identify what are acceptable values for these process parameters. The consequential interpretation of this is zero tolerance for process variability, which is not achievable. A good project has
measurable CTQs with measurable response variables (Goldstein, 2001). Consequently, before the DMAIC implementation could proceed, these factors had to be identified.

**Three steps forward, two steps back**

Due to the lack of necessary data, the Measure and Analyze phases needed to be revisited before the implementation could resume. Thus from a strict DMAIC perspective the only stage that had been faithfully completed was Define.

During the Define phase of DMAIC project there are several key deliverables: identify the customers and their needs, establish the boundaries of the process, and define it though process flow mapping (iSix Sigma, 2009). For the BOM DM project, the process had been mapped in thorough detail and careful consideration had been given to ensure that the appropriate boundaries of the process had been chosen. Since the desired output, an optimally aligned BOM, requires many different pieces of information to be relayed to the product engineer (PE), the process actually extends beyond the Product Operations job functions. Recognition of the internal and external influences was key to accurately mapping this process. However, since each BOM is unique there are few universal CTCs other than production delays.

**Measure Revisited**

With the Define phase completed and thoroughly reviewed, focus was shifted to the Measure phase. The key activities of the Measure phase are: collect data that describes the “as is” process and review the data to determine the sources of defects. This phase should reveal a collection of process parameters, characteristics that influence the CTQs.

**The data collection plan**

Measurement of the BOM development process turns out to be no easy task. The concept of identifying and measuring process parameters is fairly straightforward when measuring a manufacturing process such as making golf balls. This high-rate production process lends itself to Six Sigma process improvements because the process parameters are intuitive as they are similar to the manufacturing steps, and each occurs hundreds of times per day thus facilitating measurement and data collection. Furthermore, the product is consistent with well-understood tolerances so the quality level is evident. However, each Cisco product is unique, each customer has a different set of requirements, and the supply chain design is in constant flux thus each bill of materials takes a distinctive format. The process parameters that directly impact the BOM structure are all based on the conveyance of information to the PE. Whether or not a crucial piece of information was relayed creates a black and white process boundary with zero tolerance. So while it is easy to identify the most common BOM structure influencing factors, it is difficult to determine if an exclusion of one is an error or just non-essential for that product.
This type of pitfall occurs sometimes when using the DMAIC tool to implement business process control in a non-manufacturing environment. Processes that are flexible are by virtue difficult to control and data is hard to come by. So a data collection plan was developed which took a two-step approach. The first was to scour the existing performance metrics for new product introductions (NPI) to see if they could shed some light on the issue. The second was to perform some measurement analyses to fill in the missing data from the metrics search.

**Search other metrics for existing data**

In BOM development, the breakdown occurs when information is not utilized to appropriately influence the BOM structure. This occurs because either the customer and supply chain facing teams do not relay the information to the PE through the proper channels, or the PE does not understand how this information has an effect on the BOM. The solution to this is quite obvious: create a vehicle to facilitate the transfer of this information and give the PE cause to consider how this information affects the BOM. However, the measurement of such a process is extremely difficult when the critical information is different each time the process is run.

There are ways to measure the flow of information by exploring the heritage information-transfer mechanisms. In NPI, the primary mechanisms are the phase-gate meetings and product requirements document (PRD). It would be simple enough to measure the completeness of the PRD for each product however:

1) The PRD is not intended to be 100% complete because it contains more information than is necessary for each product
2) Many times the information to complete the PRD is not decided until later
3) Sometimes the requirements change

For these reasons there were no clearly established process parameters to measure the quality of information flowing to the BOM creators at that time. This was confirmed by a review of the NPI Metrics tool and PE Balance Scorecards.

**New measurement techniques**

**ECO Search**

One way to measure the size of the problem, and the associated benefit of a solution, is to examine the cost associated with Engineering Change Orders (ECOs) that are generated to correct BOM structuring errors. Cisco associates an average cost to each ECO, which covers the time needed for investigation, creation, approval, processing, and carrying out the disposition. Determining how many ECOs per year can be avoided by a successful implementation of this project and multiplying that by the associated cost of each ECO is one way to assess organizational impact.
Bear in mind however, that when determining the impact of a project, it must be measured relative to the original project goals. Though the primary identified goal of the BOM DM project was to fill a gap in the CPDM process, the motivation for that was reduce negative impact to customers. In addition to the savings gained by preventing ECOs, there is a financial benefit from improving customer satisfaction, which will be realized through future business. While measuring the value of customer satisfaction is a very subjective endeavor, it is a straightforward task to measure the number of customer impacting events. For simplicity, this study will assume that a constant percentage of ECOs results in a customer-impacting event, therefore we can create a measure for customer satisfaction by measuring the volume of ECO generation. The reasoning behind this assumption is as follows: ECOs are only generated to release an engineering design, or change a previously released design. Only design change ECOs are being considered for this analysis, which implies that either the first shipment has already been sent to the customer or the first shipment will be delayed. Either case negatively affects customer experience. When design changes are approved the NPI teams increase their efforts to avoid delays as much as possible, so it would be ignorant of these efforts to claim that all ECOs result in a customer impacting event. However, while the team may be able to compensate for errors by working extra hours, this is not desirable either. The ideal solution is that these errors be avoided in the first place.

There were over 25,000 ECOs generated in 2008. In order to identify how many of them are associated with this specific problem they were sorted by root cause. In the CUP/GECO management system does not maintain search functions for every field in the ECO, which would be necessary to simply filter the appropriate ECOs. Therefore a sample selection was taken and the ECOs were reviewed individually in order to identify the root cause of the design change. Several months were chosen at random for sampling and the results were extrapolated to generate yearly averages. This method is valid assuming that there are no cyclical patterns, such as seasonality effects, on ECO generation.

Of the 25,000 ECOs for the year, 3286 were BOM related. Of those 170 required a design change that was not initiated by a change in customer requirements. This implies that the total size of the problem has an upper bound of about 170 events per year. Given the average cost per ECO in fiscal year 2008, a 100% solution would save Cisco over $2 million per year, not including the financial benefit of new business related to higher customer satisfaction.

Any Cisco manager will agree that a problem of this magnitude is worth investment in a solution. The issue remains that there is no comparison between the magnitude of this and other systemic problems. This would be needed to justify prioritizing this project over others. Furthermore, this method does not identify the lower bound on the magnitude of this solution.
Qualitative interviews

Groups involved with product launch (post BOM creation) agreed that a more standardized BOM was needed to bring a consistent product to customers, facilitate fulfillment, and increase future scalability. This includes the groups within CVCM such as the product data team (PDT) and global supplier management (GSM). However, these groups viewed this as someone else's problem and though it caused them hardship, it was product operations' responsibility to fix it.

Groups involved with creating the BOMs agreed that a tool was needed to make BOM creation simpler and easier. Their actual objective was to create a tool that would take input from the PRD and output a completed BOM. However, their acceptance of a solution was conditional based on it making their job easier. When confronted with the errors and customer dissatisfaction caused by BOM mistakes each individual claimed that a solution was necessary for the community but not needed for them. A few groups owned up to having made BOM structuring mistakes but all claimed that they had learned from them and a preventative mechanism was not needed. In all, a handful of individuals recognized the true value of this solution but also claimed that energy should be focused on other, more pressing problems. All in all, stakeholder approval of the concept was high, but very few individuals were willing to change their behavior. Furthermore, most individuals felt that there were bigger fires to fight.

Create new metrics to track the problem

Since the data collection plan had not yielded statistically significant findings, the final option was to create them. During the ECO analysis, many individuals did not fill in the root cause for the change. The next step would have been to put metrics in place to require that information be recorded. Preceding this would be adjustments to the ECO tool and training. Another option was to create a virtual workspace that managed and tracked the transfer of all BOM related information to and from the PE. Alterations to both of these systems would require replacing a piece of paper with a software solution, like a wizard. This alone would take 8-12 months and require its own business case analysis to justify. Utilizing the existing systems, such as creating a new NPI metric would not suffice since they were not auto-populated but were dependent upon qualitative user input. Thus, creating a system to procure the necessary data was outside of the available resources and timeline for the BOM DM project.

According to one process engineer, this is a common scenario at Cisco. Because a comprehensive data-tracking infrastructure is not already in place, often times it would take four months to record the background data needed to accurately measure a problem for which the solution must be rolled out in one month. So minimal and partial data are collected or the implementation continues without the appropriate supporting empirical evaluation of the impact.
Findings

Cisco is about three years into a six to eight year journey to truly embrace Six Sigma in its operational processes. The Customer Value Chain Management group has developed frameworks to guide manufacturing excellence (MX) and quality excellence (QX). As managers find that they need help reaching the performance goals required by these frameworks, they look to Six Sigma for help. However, many groups have not reached this point yet and are still wondering, “Why do I need to bother with data?” For these groups, implementing meaningful process controls and achieving statistically significant continuous improvement will continue to remain a challenge.

In the case of the BOM DM project, without a proper Measurement phase, the project could not proceed to the Analyze, Improve, and Control steps. During the Analyze phase the measurements are reviewed and a gap analysis performed to verify that they are sufficient to define the process, as it should be running. This step cannot take place until the process is appropriately measured. During the Improve phase, the key performance metrics as well as an acceptable range of variation in which the process will still yield desirable outcomes are identified. Without the appropriate CTQs, these metrics and ranges cannot be determined. During the Control phase, the process changes are put into place and monitored through statistical process controls. As the process is performed over and over these metrics are continually monitored and the acceptable limits are revised if they turn out to be either too restrictive or not restrictive enough to yield a quality result. Of course, this step cannot be reached without faithful completion of all the previous phases (Harry, 1998).

It was estimated that proper measurement of the process parameters and project impact would take several months of data collection in order to baseline the current condition accurately. This information was presented to the management for further direction. Upon review, management concluded that given the time and resource constraints on this project, the data collection would not be possible and a modified implementation approach would be needed such that a solution could be realized within the desired timeframe.

Project Redirection

Though it was not possible to continue the DMAIC implementation without a complete Measurement phase, the Product Operations group decided to continue to roll out the newly defined process. However, since the data analysis needed to bolster the impact of the project was not available, a new approach was needed. In choosing how best to go about this, the team understood that the new approach would not have the indisputable evidence that justifies hard rules around behavior. So a new implementation strategy was pursued that presented supporting evidence but allowed stakeholders to decide for themselves if the process was helpful.
Stakeholder commitment

In order to drive adoption, this project was presented as a collection of pre-existing business practices at “stakeholder inform meetings”, a series of interactions held to build stakeholder commitment. For those who appreciated the value of the impact, the proposal was readily accepted. To convince those more hesitant, it was argued that individuals who were already familiar with the current best practices, the new process would require no deviation from their current activities. Since the BOM DM is based on current practices, only those who do not employ Cisco best practices are required to change their habits. All complaints about the hardship of adoption ceased at that point since continuing would imply that they presently violate the best practices of the company.

Another technique to drive stakeholder commitment was to tell convincing stories for why this project is important. Primarily, the story of the project motivation as described in Chapter 2 provides a clear-cut example of how things can go wrong downstream because of seemingly innocent BOM structuring decisions. This story brings an abstract concern, the consequence of a simple oversight, and embeds it into a common scenario faced by these engineers daily, thereby making the concern more realistic and “sticky”. In 2001, Stephen Denning published a book called The Springboard in which he describes how “springboard stories” can be used to create buy-in from stakeholders (Heath, 2007). At 3M, “strategic narratives” (or stories) are used extensively in process planning. Their claim is that using bullet points to make a claim is too generic, leaves critical relationships unspecified, and leaves out critical assumptions. Stories, on the other hand, pull all of these pieces together in a presentation that is both relative and memorable (Shaw, 1998). Strategic stories told in a “it could happen to you” format help to individuals to recognize that although in abstraction it is easy to know what to do, the picture becomes cloudy during the course of everyday events. Given that adoption of the BOM DM would be voluntary, the team told the story from chapter two at the beginning of each stakeholder engagement in order to frame and provide context for the problem, and gain support from future adopters.

In order to drive voluntary adoption further, the implementation team committed to creating tools and training to make the process as user-friendly as possible. This was enough to get the key stakeholders, the Mechanical Project Engineering (MPE) managers’ council and Electrical Project Engineering (EPE) managers’ council, to commit some time from their teams to test and develop the process.

Develop user-friendly interface tool

Concurrently, the team developed a tool to make the process more user-friendly. Given that the new “guidelines” allow the user more free will to adopt, they must be as straightforward and simple to follow as possible. The BOM DM at that time took the form of 18 11”x17” pages of workflows accompanied by 35 pages of text. A process defined in such detail takes an individual up to a week of concerted effort to fully digest. Thus, it was obvious that the process must be presented in a more palatable format.
The BOM Development Methodology workflows describe a series of complex decision trees. In order to guide users easily through the tangled web of pathways the team wanted to employ a “wizard” type of solution which leads users down the appropriate path, or series of parallel pathways, dependent upon their answers. A simple investigation uncovered that the programming skills required to create such a software solution were again beyond the resource requirement for this process. However, Microsoft Excel contains many pre-programmed functions that could be used to perform such tasks. The tool would then take the shape of an automated checklist, as see in Figure 14. Each of the over one hundred steps in the process map was rewritten as a task, to which the user could respond as to whether the step had yet been completed by selecting a “Conclusion” from a drop down box: “Yes” or “No”, or leave the cell blank and answer it later. These answers served to mark that the step was complete and also to determine what the next appropriate question would be. In a blank form, every question appeared on the checklist but as questions (or “Considerations”) were answered, other considerations that are no longer pertinent would collapse away.

![Figure 14 - BOM Development Checklist](image_url)

In addition to instructions and hyperlinked reference documents, the checklist also includes columns that reference the specific requirement in existing Cisco documentation and give examples of when these considerations are important. In addition, users are encouraged to add comments on why those specific conclusions were chosen. Finally, the Actions column gives the user a task to complete before moving on to the next consideration.

The result is that if a BOM creator works his/her way through the checklist answering each question in order and completes all checklist items, the collection of information and completion of actions will satisfy all requirements of the BOM DM. This “user-interface tool” greatly simplifies the complexity of following
the process. In order to make this even easier for product engineers to follow, a 20-minute video training module was created and distributed to all NPI managers as seen in Figure 15. This voice-over-Powerpoint walks individuals through the process and functions of the BOM Development Checklist.

Figure 15 – Screenshots from the BOM DM training module

Throughout the development of the checklist, the tool was vetted through a piloting process, which is described in the next section. One of the key learnings from this process is that automation is key to drive adoption. Our goal as process engineers is to create foolproof procedures that do not give users the flexibility to make mistakes and simultaneously demands less effort than before to complete the task. Automation is an effective way to accomplish this when used appropriately. Legendary process pundit Michael Hammer warns, “Automation simply provides more efficient ways of doing the wrong kinds of things” (Hammer, 1993). We must be careful to recognize that automation is not a solution; it is a tool to help reach a solution and must be used wisely.

Piloting

With the BOM Development Methodology reviewed and the user-interface tool in working order, the team began to test it in an iterative manner. Pilot projects that span the range of product complexities, volumes, and production models were selected. Pilots are like experiments that test the solution and create an opportunity to learn.

Experiments performed in an iterative manner create an opportunity to learn and improve the solution with each run. Early tests create huge learning opportunities and if the solution is refined between each experiment, the learning opportunities diminish over time. This concept is analogous to the argument made by Griffin and Hauser in their paper, “The Voice of the Customer.” Griffin and Hauser posit that percentage of known customer needs increases with each interview and eventually begins to level off, as shown in the left graph in Figure 16. This trend is analogous to the number of necessary changes to the BOM DM identified per pilot. The right graph Figure 16 depicts the learning curve from the BOM DM pilot program.
Although the Y-axis units are essentially inverted between the two graphs, they demonstrate the same principle. This concept was applied to determine the number of pilots needed to test the BOM DM. The early BOM DM pilots were tested on simple products while the later pilots were tested on more complicated production models. This fact, coupled with the fact that in the later pilots a higher percentage of the changes identified were semantic or grammatical, indicated diminishing returns from further piloting.

Qualitative polling also provides a means to verify that the process is ready to go live. After completion of the final pilot, a survey was sent out to all participants to gather feedback before initiating the rollout. Figure 17 displays the results of that survey.
There are several interesting findings from this feedback. Based on the answers from the first two questions it appears that NPI teams support that the BOM DM will improve their interactions and understanding of the BOM development process. The majority also believes that this methodology will be useful for training new individuals. On the other hand, the majority also believes that the BOM DM will not help them personally to develop BOMs, or reduce BOM structuring errors warranting ECOs. One explanation for this is that the engineers involved with the pilots and surveys were those most familiar with the BOM development process so they believe the methodology will not further their understanding. Also recall, that the BOM DM was created by recording best practices already in use by these individuals. So for some, the BOM DM contains little or no new information.

Even with this in mind, this evidence does not support that the BOM DM is a sufficient solution to the original problem of BOM related issues creating customer-impacting events. Nevertheless, project leaders decided to continue with the rollout because they saw it as a step in the right direction.

The rollout process

With the pilots completed and the tool and process validated, the team could finally begin the rollout. Again, the primary focus of the team was adoption, so to drive that three techniques were employed: adoption contracts, process training, and compliance monitoring metrics.

Adoption contracts are used at Cisco to create accountability for process users. The contract allows individuals in a target group to commit to the process and choose the date at which they plan to be compliant. When the “guideline” strategy is utilized, stakeholders have more freedom so compliance requirements and actionable enforcement are not valid. By having the stakeholders sign an adoption contract, they are now held accountable to the process by their own terms. Sometimes individuals attempt to opt out of the contract, as was the case for the BOM DM implementation, however, presenting the volunteer rates of their peers can easily realign them. Typically, when standard practices documents are updated, there is no training or memo sent out to notify users. To drive even higher levels of awareness and usage for the BOM DM, the 20-minute video training module described previously was added to the required curriculum of all users.

With contracts in place and training available, the last step in the rollout was to create metrics to monitor that users are actually following through. The preferred tool in the Product Operations group is the NPI metrics system. This system collects function-specific metrics, which used to grade efficacy of NPI teams. By adding a new metric to monitor utilization, the BOM DM becomes part of the standard NPI processes.
Project Results and Analysis

Implementation Results

The goal in choosing an implementation approach should always be to drive adoption/acceptance of business processes. This objective was the primary focus when developing and testing the process.

Initial adoption results

Qualitative feedback from stakeholders who elected to participate -- recall that process adoption was voluntary -- indicates broad support of this initiative. Of the groups to which adoption was proposed, 92% agreed to use the new BOM DM. When making the decision to adopt, many groups relied on the opinions of members who had participated in the process development and testing. As indicated in pilot feedback results, though some individuals understood that the BOM DM would not significantly change the environment, they believed that it was still helpful for the team and important for the company to have standardization.

![Figure 18 - Results from adoption contracts](image)

Six month review

The BOM DM officially went live with the release of the updated BOM Structuring Policy in August of 2009. The NPI metric described in the previous chapter was deployed on August 31, 2009. At that time it was embedded in Cisco Manufacturing’s project tracking tool as a task, which reads “Was the BOM Development Methodology (Section 14 of BOM Structuring Policy - EDCS-700334) applied in the definition/structuring of the PIDs?” As of January 25, 2010, twenty-one projects have met the above criteria and have applied the process. There has not been any negative feedback from these projects/users brought to the attention of the Product Operations group.

One improvement opportunity identified so far is to reset the due date for this task. Currently the due date for the task is set to show up late in the product development process. It should be moved to an earlier point in time so that it is not an “after thought” to the work. The Mechanical PE GPO will be engaged to resolve this issue.
When following the BOM DM process, the last step is to upload the completed BOM Development Checklist to a central repository for reference. This is useful for several reasons:

- Future product engineers can reference the checklist to understand the important criteria when setting up BOMs for similar products.
- If there are any issues with the product BOM structure later on, the checklist can be reviewed to gain insight into the cause of that problem.
- The BOM Checklist Library provides a simple check to see if BOM DM process is being followed to the final step.
- A repository of completed checklists creates a valuable data set for future product operations managers to make continuous improvements to the BOM DM.

Although twenty-one project managers claimed to have followed the process, currently no completed checklists have been uploaded to the SharePoint site. Follow-up with these managers revealed that the way the metric is written, green rating indicates that there were no conflicts with the BOM DM when generating this BOM. Given that the BOM Development Checklist is just a tool to help engineers follow the standards described by the methodology many experienced engineers do not need the tool to meet these requirements. Similarly, less experienced engineers will not require the tool either when working on routine or less complicated products. Furthermore, several of the twenty-one projects were products below the PID level, thus the BOM DM does not require any action in order to be compliant.

Another way to understand how deeply this new process infiltrated the system is to examine how many people completed the training module. A report run on January 7th, 2010 indicates that 25 product engineers had completed the training thus far. That is roughly about half of the individuals for which this training was intended thus the BOM DM is only half way to full adoption.

The only real risk identified at the onset of deployment of this new process was that adoption levels would be low. After 5 months of in the system uptake is occurring at a rate that satisfies the Product Operations team.

**The Effectiveness of the Solution**

As planned, the choice to abandon the high level of control allowed the new process to be implemented within the desired timeframe. While the new process successfully serves to fill a gap in the CPDM, the motivation of that effort was to reduce customer-impacting events caused by improper BOM alignment. At this point, important process controls needed to manage this are still missing and there is a lack of evidence that the organization is better off from this perspective.

Earlier in the project, the size and impact of the issue was quantified through an Engineering Change Order (ECO) analysis, as was described in Chapter 4. Performing a post-implementation ECO analysis can give insight into the project impact, though we cannot statistically attribute these results solely to the BOM DM project.
Comparative ECO analysis

Through the same methods described in Chapter 4, another ECO search was conducted. Since the BOM DM rollout, we cannot claim that the situation has improved based on ECO analysis. While the analysis indicates that more errors are being made (170-256 ECOs per year at the current rate vs. 93-170 per year at the previous rate) the rate of new product introductions has also increased for this time period. However, even normalizing for the number of products in the pipeline during that period, the ECO generation rate does not appear to have improved. It should be noted that the new system has not been in use long enough to procure a significant number of data points. Furthermore, the BOM DM has not been in use long enough to fully purge the old process from the system. It is important to recognize that it will take more time before the full effect of the process change will be realized.

A major finding through the ECO analyses is that many ECOs only describe the change and have incomplete root cause and corrective action analyses. This makes it very difficult to understand if the change was due to an error in setup or a change in customer needs. It requires great discipline to perform thorough root cause and corrective action analyses and when groups are implementing a great number of changes it is easy to forget about these sections. As this project demonstrates, this discipline is needed to give future managers the insight to make impactful changes.

Final Results

Upon final review three important results about the implementation of the BOM DM become clear:

- The Global Engineering and Operations group has filled another process gap by releasing an official process that documents the best practices of BOM development.
- The user community has voluntarily adopted the process and it does not appear to have placed a significant burden upon them.
- There is no evidence that this solution has had a statistically significant impact on the issue of BOM structuring errors, which was one of the original motivations.

Based on the limited data available, it is not possible to claim that the original problem that motivated this project has been fixed or even bettered. However, it may be the case that the true value and intention of the project turns out to be entirely different. Recall the charter of the GEO group: to create value through operational excellence and manage the processes to enable the company. Whether or not the BOM DM has cured improper BOM alignment, it has created an approved standard and expectation for bills of materials, which has great value in training and scaling up with new acquisitions. GOOD POINT

Implementation Analysis

To recap, in the product operations group the standard technique for defining a new process is DMAIC. The original approach for this project was abandoned when the time and resource constraints precluded a faithful implementation. The strategy was modified in order to gain the most value for the
company. While the GEO group recognizes the usefulness of DMAIC and other Six Sigma strategies, for extremely nebulous and complex processes sometimes a basic sense of order needs to be put into place first. Without that, it is difficult to remain focused and easy to get lost in the details an undertaking such as DMAIC. This can be thought of as a first step in a milestone approach to process efficiency.

**Spectrum of control**

In the end, the strategy we choose to manage a business process must be consistent with the level of control we wish to exert over the environment. When looking at the spectrum of control shown in Figure 19 each project can be associated with a point or range of points on this spectrum.

![Figure 19 - The spectrum of control](image)

When a project leader's control over the project environment is high, it is possible and desirable to enforce rules, which bound the process and limit the actions of those who perform the process. When control over the environment is not strong enough to enforce rules, creating guidelines or best practices that define the process and demonstrate why it is desirable, is a desirable approach. Furthermore, when control is low, it may be that the only way to influence a process is through inspiration.

A proper DMAIC implementation yields a well defined process with parameters acting as control levers which must be managed to remain within prescribed boundaries at all times. The result is a very strict process, which must be followed without deviation or interpretation. In order to drive high adoption of such a process, stakeholder support must be extremely high and the ideals must be championed and supported by management at all times. Conversely, when stakeholder support is moderate, it is not likely that a strict set of rules will be followed so faithfully. For the BOM DM project, managers chose to do exactly this and rebranded the initiative as a set of guidelines rather than measurable and enforceable rules. Conversely, requiring engineers to complete a BOM Development Checklist for each new product and save it to a central archive that would be audited at random, creates a measurable way of ensuring that the process is being followed. A strict DMAIC implementation would have resulted in requirements such as this to ensure adherence to the new process. Given that a guidelines based approach was taken, this approach was not taken.
There are key factors that are important in determining the most appropriate point on the spectrum for a process control initiative.

- Availability of data
- Perceived value of data
- Culture of the organization
- Impact of the project on the organization
- Support of stakeholders

The first and most obvious on the BOM DM project was the availability of data. As discussed in Chapter 2, measurements on the process parameters, CTQs, and impact to the company are needed to support DMAIC and no systems had been put in place to record these for BOM related issues, as seen in Chapter 4. In the absence of plentiful quality data, high levels of process control are not supported.

Closely related to this issue but not quite as visible was perceived value of data within a group or organization. Every company must decide for itself how much data analysis is necessary to back each decision and when is it appropriate to pull the trigger. While Cisco is known for having concretized itself in the networking electronics market, it has achieved this by remaining ahead of the competition though new and innovative product introductions. In order to achieve this type of speed to market, many decisions must be made quickly, which implies that there is less time to collect and analyze data. At 3M, the company encourages the value of entrepreneurial behavior even to the degree of supporting “well-intentioned failure”. One of their four key fundamentals for success is giving individuals the room to grow, try new things, and learn from their mistakes (Leavy, 2005). This means trusting people to make decisions without requiring reams of statistical data and justification. In this environment the opinion of subject matter experts is highly revered. In the words of Bill Gates,

“...You have to listen carefully to all the smart people in the company. That’s why a company like ours has to attract a lot of people who think in different ways, it has to allow a lot of dissent and then it has to recognize the right ideas and put some real energy behind them” (Leavy, 2005).

Another equally successful value proposition is one embodied at Intel Corp. Intel has dominated the PC microprocessor market by making reliable, high-performance chips at a reasonable cost. Intel is generally recognized as successful in achieving this through an almost religious focus on accurate decision making well supported by data. The implication for process management decisions is that even with plentiful data, strict process controls or rules will not be supported by a group that does not appreciate the value of it.

While this value system is likely not written down in a reference manual, it becomes apparent through study of the corporate culture. In his pyramid model of culture, Emeritus MIT professor Ed Schein says that like an iceberg, the majority of corporate cultural influences lies below the surface and are not readily seen. Cisco has grown inorganically through its many acquisitions, each an entrepreneurial venture of its
own, and as such has a strong culture of entrepreneurship, innovation, and creativity. These assets help the company maintain its speed to market. Though the company strives to implement strong Six Sigma initiatives, and is widely successful in many instances, it sometimes fails because these values tend to contradict the values needed for these initiatives. In a NY Times article titled “Welcoming the New, Improving the Old” author Sara Beckman discusses how an operational efficiency focused group tends to approach business from a different perspective than a group focused on innovation through focus on customer problems and vice-versa. This popular focus, called “design thinking”, requires a set of skills that are complementary to those of Six Sigma and other quality control system advocates. Chuck Jones, vice president of global consumer design at Whirlpool says,

“Design thinkers are like quantum physicists, able to consider a world in which anything — like traveling at the speed of light — is theoretically possible. But a majority of people, including the Six Sigma advocates in most corporations, think more like Newtonian physicists — focused on measurement along three well-defined dimensions” (Beckman, 2009).

Both sets of skills are important in successful companies of today. The history pages are littered with companies that were driven under by market leaders whose operational strategy afforded them products built cheaper, better, and quicker than competitors. This is exactly why quality management initiatives have been so popular over the last few decades. Conversely, design thinking helps companies create products to stay ahead of a constantly changing market. In the famous speech made by Larry the Liquidator (played by Danny DeVito in the 1992 film “Other People’s Money”) he addresses the stockholders of a dying company and says,

“You know, at one time there must have been dozens of companies making buggy whips. And I’ll bet the last company around was the one that made the best god damn buggy whip you ever saw. Now how would you like to have been a stockholder in that company?”

Design thinking helps companies keep their ears to the customer and prevents being the last company making buggy whips. Thus, the successful companies of today’s business world will be those that encourage and support both skill sets (Beckman, 2009).

Typically, it is the case that a company with a strong corporate culture favors one of those two opposing skill sets. Studying the corporate culture of the organization will quickly uncover the generally agreed upon values. This is important information when choosing how to approach a process control strategy. Referring back to the spectrum of control, rules will most likely be accepted in a strong operational efficiency culture while guidelines and inspirations are more likely to be accepted in a design thinking or innovative culture.

Another important factor to consider when making these strategy decisions is the impact of the project on the organization. When Cisco implemented a new enterprise resource planning (ERP) system in
the mid-nineties it spent years collecting data, researching tools, testing, piloting and rolling out the system in a data-driven decision making fashion. Projects with the magnitude capable of toppling the company require strict rules and process controls. On the other hand, the BOM DM project was a fairly low impact improvement, which may not have even warranted such a detailed approach.

Of course, all of these factors are aimed at understanding the level of stakeholder support. This is truly the critical information that indicates if the chosen implementation approach is suitable. The most important thing is that those who will be affected by the change agree that it is best for the company.

**Freedom and responsibility**

A famous consultant was asked by a fast food company to perform an operational efficiency study on their process for making milkshakes. They had just introduced a new line of flavors, which greatly increased the complexity of the operation and accordingly they were suffering from efficiency losses. In the process of making these milkshakes there were a series of machines that each dispensed a different component to the shake. It was the employee's responsibility to move down the line and add the appropriate ingredient from each machine. The company had attempted to recover by standardizing and automating the steps as much as possible but had not yet seen desirable results. One example of this approach was to automate each machine to dispense only the exact amount needed for each sized and flavor. However, if the employee spilled some of the mixture before adding the last ingredient, pushed the wrong button, or the machine did not dispense the correct amount, the inflexible nature of the process forced the employee to throw the shake away and start all over. The study uncovered that in attempting to prevent human errors, the rigid process had also denied the employees the freedom to fix or accommodate random and human error.

The term “F-form”, or “freedom-form”, is used to describe an organization that rejects the use of rigid processes to control the actions of employees. Here employees have not only the freedom but also the responsibility to do that which they decide is best for the organization. Companies of this ilk range from Southwest and Toyota to Quad graphics, a company with no org chart where everyone from the CEO to the secretary is equally free to make decisions that they think are best for the company (Getz, 2009). Companies such as these prevent situations like the milkshake example by empowering the individuals with control over their actions, which seems to lead to higher assumed levels of responsibility and greater efficiencies.

Creating systems and processes that only employ “constraints that deconstraining” (a concept introduced by Kirschner and Gerhart which argues for process constraints which deconstrain other aspects) is part of Cisco’s strategy to remain creative and innovative. In the case of the BOM DM, the flexible guidelines approach was well received because it did not over-constrain a complex process or remove the freedom of employees to respond to changes in an environment of high uncertainty.
Myths about process management

It is true that strict process controls such as Six Sigma and TQM have yielded fantastic successes for companies like GE and Motorola. Managers at these companies have demonstrated that process control leads to operational efficiency. This section breaks down the process management myths that may prevent successful implementations.

Documentation for documentation sake

While it is true that standard work improves efficiency and documentation is needed to define these processes, there is danger in creating excessive documentation. As standardized processes propagate and become more elaborate they sometimes create a complex and tangled web of solutions that burdens the users. At this point, the documents and standards are no longer achieving their intended value. Appendix A demonstrates how a process such as DMAIC can be cross-referenced and entangled with too many other processes to the point where it is too cumbersome to follow. As mentioned in Chapter 3 the BOM DM was created to fill a gap in the CPDM. Though there were other advantages brought about by the BOM DM, it is sometimes specious to assume that filling documentation gaps will lead directly to process optimization, as was shown in Figure 6 back in chapter 2.

In the Product Operations group at Cisco, there is an effort to simplify these processes to reflect just the critical aspects. The “maple syrup analogy” is used to depict this concept. Leaders in product ops are attempting to boil down the stew of processes leaving behind only the most valuable ones. This process is analogous to the process of making maple syrup, whereby the sap of maple trees is collected and boiled down until a thick golden syrup remains. As an example of how important it is to remain diligent about this, a search was performed to find all references to a specific process in the electronic document control system and yielded 429 findings. With a convolution of references this severe it is likely that this process cannot be performed successfully.

DMAIC for all

According to an article published in Business Week in 2007, “the notion of Six Sigma as a corporate cure-all is subsiding.” The article claims that for innovation and invention arenas, the DMAIC mind-set does not really make sense. According to Robert Carter, a consultant for Raytheon, when a new idea starts to take shape “you don’t want to over-analyze it” (Hindo, 2009). While Six Sigma is a powerful tool for improving quality and cutting costs and despite the fact that celebrity CEOs like Jack Welch have rammed it into every aspect of their businesses, Six Sigma is not the tool for every job.

In addition to its tendency to fog the creative spirit, the Six Sigma approach is overkill for improvements of the minutia. Home Depot’s former CEO Robert Nardelli, a disciple of Six Sigma, applied the approach to everything from the check-out process to the placement of vacuum cleaner displays.
Nardelli’s exuberance for operational efficiencies drove company profits, while customer satisfaction tanked as associates spent more time collecting data points than assisting patrons (Hindo, 2009).

As described earlier in the analysis, managers must gain insight into the appropriate strategy for process controls. When needed, they must be willing to fight the historical precedents that have entrenched the group in a singular line of thinking in order to create the most value for the company through operational efficiency.

**Conclusions and Recommendations**

In the end, the goal of any process control initiative is to create value for the company. It is often a difficult balance to gain the most value for the company with the least amount of resources consumed. In the case of the BOM DM there certainly was value gained for the company by defining a previously undefined process and creating intellectual property for the company documenting the best practices. This methodology, even if not used by everyone will certainly make a valuable training tool for individuals new to the product-engineering role. It is legitimate to assume that implementing the BOM DM with a stronger compliance requirement would have curbed BOM structuring errors more efficiently, but at this point no data exists to indicate that it would be the best use of resources for Cisco. This chapter will explore these tradeoffs with the goal of empowering managers to make the right decisions on future process control initiatives.

**The tradeoffs for the BOM DM**

**Expedite a low impact project**

As seen in the Home Depot example companies can get bogged down in small impact projects that can ruin productivity. Many companies, Cisco included, are fighting a constant battle against red tape. Angel Mendez, senior vice president of CVCM, claims that he “hates bureaucracy” and makes it his personal mission to remove the red tape that slows productivity. When it comes to low impact process improvements, lengthy studies and complicated solutions requiring armies of resources to monitor compliance are just not efficient. For the BOM DM project, the kind of effort needed to carry out a faithful DMAIC implementation may not have been warranted at this time. As Michael Hammer, former MIT professor and father of business process re-engineering (BPR) once said, “Any process is better than no process.” For many low impact process control initiatives, just getting something in place quickly and cheaply is a valuable first step, upon which more complex controls can be built in later as needed.

Of course there is no clear definition on what a “low impact” project is. It is left to the manager’s discretion to decide how important the process is to the company’s ability to function efficiently and weigh that against the amount of resources needed. Again, a company for which Six Sigma is a way of life, will
likely be more efficient at strict process control initiatives and can utilize this on lower impact projects than a company in a less structured environment.

**Leverage speed and innovation culture**

As discussed in Chapter 6, while some CEOs like Jack Welch say that Six Sigma should be applied universally and, even though it may not always fit will be worth it in the long run, companies today are trying to encourage both the operational efficiency mindset and creativity. However, saying “Let’s do both Six Sigma and be creative” sends a mixed message to employees (Hindo, 2009), which leaves many companies leveraging one side and doing the other where they can. Though Cisco has executed some textbook Six Sigma initiatives, its core remains creative. When forced to choose sides, it is often more productive to go with the current. The BOM DM enables creativity and flexibility around a nebulous process while still creating boundaries and guidelines for the routine aspects. This approach promotes the core values of Cisco. Chapter 6 also discusses how challenging legacy perspectives is important at times, but often the greatest lift can be from riding the prevailing winds.

**No measurable record of impact**

The definition of tradeoff implies that something must be sacrificed in order to gain something else. For the BOM DM the benefits of minimizing resources and promoting core values came at the cost of measurable impact. One reason companies spend so much money on Six Sigma initiatives is so that in the end they can statistically defend the conclusions. Statistically significant data illuminating the financial impact of this project does not exist. The analysis given in Chapter 4 gives a few estimates but forfeits the luxury of hard numbers.

To review the background on this project, customer complaints led to the discovery of BOM structuring errors, which were attributed to the lack of definition about the BOM development process. The goal of implementing a BOM DM was to fill the gap in the Cisco product development methodology (CPDM) with the intention of reducing BOM structuring errors and customer complaints. The goal of establishing a standard was certainly achieved. The impact to the company cannot be determined without further examining how effectively the BOM DM prevents structuring errors. This was the true sacrifice from the choice to abandon the DMAIC approach.

**Stakeholder satisfaction**

Qualitative surveys indicate that those involved with the BOM DM, both the project architects and the process users, are fairly pleased with the result. One commented that “even if no one uses the tool, at least we have a documented process where there was not one before”. The value of the IP transferred from the minds of the employees to the company is worth it alone. Furthermore, the tool itself has been readily
accepted for training purposes and will likely add value when integrated into a more automated system in the future.

The only caution when drawing conclusions about success is that success is in the eye of the beholder. Those involved might be too close to the issue to step back and see the bigger picture. Thus success cannot be measured solely by the contentment of the stakeholders. Some objective measure, which can be traced to the bottom line profitability of the company, is also needed.

**Recommendations to future managers**

From the BOM DM case study several universal lessons can be learned. The final section of this thesis pulls these together in a series of recommendations that managers can use to guide future process control initiatives. The goal is to empower managers to make the best choices on which projects to choose and how to go about them, in order to create the most value for the company.

**Identify the true value of the project**

The value of a process control initiative can be judged in many ways. Sometimes creating a defined process where there was nothing before is valuable and sometimes there is no value in the exercise unless a problem is solved. Before considering how to approach an initiative, managers should consider what outcome would make this project a success. To help managers identify the value of a project they should consider the effect on each of the categories in the figure shown in Appendix C. The figure depicts the effect that business processes have on the greater organization. Understanding how the problem and its proposed solution affect each aspect will help managers define the value that it creates.

**Get the most bang for your buck**

Often managers will have several optional projects to consider. It may be tempting to choose the easiest project or the most expensive one because it has the biggest impact. For process control initiatives some simple investigation up front will help to identify which project will have the most value for the company. Project managers should avoid situations where the project that costs the least to execute and has the highest return to the company is not chosen because of external pressures such as mandates or favoritism. An analysis of net present value, payback period, and magnitude of investment will help managers defend the choice that is best for the company. Consider how well the initiative fits with the values of the company when estimating employee hours and costs.

**Choose implementation strategy**

Once the best project is chosen, managers must choose an implementation strategy. All projects should begin with an investigation of the following:

- Dollar value cost of the problem which this project solves
- Process measurements to understand when/where the problem occurs
• Dollar value of the cost to implement a solution
• How the project will repay itself over time

If all of this data can be procured, the manager will have a strong understanding of the problem and a high level of control over the solution. Referring back to the spectrum of influence, this gives the manager the luxury of using strict rules to bound the process. The less data available, the less control the manager will have and he/she will need to come down the spectrum of influence. When a problem is not supported by data or is impractical to control managers must use inspiration or encouragement to control the process. Understanding the level of control from the beginning of the project allows managers to make more realistic decisions when defining and implementing the process.

**Identify how suitable a project is for DMAIC**

Even when the level of control is high, DMAIC should not be employed just because it is the standard mechanism for improving existing processes. Although Lord Kelvin said that “if you cannot measure it, you cannot improve it”, Michael Hammer said that any process is better than no process. So managers must employ a better upfront process to understand if the rigor of DMAIC is valued and required for this project. Managers in the product operations group have seen many times where DMAIC projects falter because managers perform only the Define, Implement, and Control without the Measure and Analyze. These two steps are really what separate DMAIC from any other Plan-Do-Check-Act initiative and what give it the Six Sigma flavor. If M and A cannot be done adequately, the project may not be right for DMAIC. Conversely, if DMAIC is the required strategy, Measure and Analyze must be carried out faithfully.

A study performed in the UK on Six Sigma project selection surveyed companies on the factors that are most important in this decision. The evidence indicates that a good project must align with the business strategy, have a positive effect on customers, finance, and be measurable and implementable (Banuelas et al., 2006). In order to be appropriate for Six Sigma a project must be clearly defined in each of the following categories:
• Problem
• Goals
• Project tracking
• Business benefits
• Implementation schedule
• Process
• Tools
• Capability and confidence
• Process orientation

If each of these areas cannot be clearly defined in a way that indicates DMAIC as the appropriate strategy, then there is likely a better alternative (Lynch, 2003).
The last step in identifying how suitable a project is for DMAIC is honing in on the scope. An expansive organizational issue such as customer complaints must be continually drilled down until the problem can be easily understood and a simple and focused solution can be put into place (Lynch, 2003). Nebulous problems with complex and far reaching solutions are not appropriate for DMAIC.

**Use DMAIC wisely**

For thousands of years, luminaries have employed the scientific method in their relentless pursuit of discovery. The scientific method provides a structured approach to investigate, define, and improve our understanding of the world around us. Popular management science frameworks such as lean manufacturing, six sigma, total quality management (TQM), and the Toyota production system (TPS) all contain tools that closely approximate the scientific method. These tools (DMAIC, DMADV, Plan-Do-Check-Act, etc.) all require the user to make predictions based on their understanding of an issue, to test those predictions through experimentation and measurements, and leverage newly gain understanding to support or modify the original hypothesis. These frameworks demonstrate how to implement this approach to business process management. But in the business world, all of this effort costs time and resources that the company must invest upfront without any guarantees for a valuable outcome. This leads to the common question, “why is it important for companies to engage in this level of rigor?”

As a thought experiment, consider the implications of a claim that “it is not worth the effort.” This can be translated to imply that the value of improvement is not worth the cost, or that the organization functions well enough without improvement. The implication is that the organization currently possesses everything required to permanently maintain its position in the market. This claim is counter to logic, reason, and the business strategy axiom that all advantage is temporary (Fine, 1998).

In *Chasing the Rabbit: How Market Leaders Outdistance the Competition and How Great Companies Can Catch Up and Win*, author and MIT Sloan Senior Lecturer Steven J. Spear describes how smart operations can be the key to business success. In it he describes four capabilities that get companies “to the front of the pack” and claims that the key to functional integration for high-performance is “specifying design to capture existing knowledge and building in tests to reveal problems”. Many companies are good at building upon knowledge of the past when developing an action plan, but high-velocity companies take the time to build in to that plan the capacity to detect failures (Spear, 2009). If we could summarize Deming’s philosophy on quality in one phrase it would be “don’t tweak”. He believed in using statistical significance to identify real problems being rigorous in solving them (Spear, 2010). Any other approach is equivalent to taking well-informed stabs in the dark. Furthermore, the impact of these actions becomes quickly indistinguishable from the noise the greater system if there is no empirical evidence (Spear, 2010).
Books like *Chasing the Rabbit* teach us how to develop operations for a high-velocity organization. In these cases, insightful managers did not approach business process management by asking “is it worth the effort?” but instead by asking, “imagine how much better we can be?” The phenomenal success of such companies can be attributed to this constant pursuit of perfection. DMAIC and the corresponding Six Sigma approach give managers a framework with which to develop this capability. As this thesis has discussed, successful DMAIC initiatives require uncompromising discipline and cultural support so managers must be prudent in their approach. However, as prominent examples such as Toyota and GE have shown us, it is worth the effort.
Bibliography


Appendix A – DMAIC References in Cisco Documentation

Alignment of DMAIC/CCR/PLC

Deliverables based on Milestones

MILESTONES

Cisco.com

Presentation_ID

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Appendix B – BOM DM Process Roadmap
Appendix C - Business Process Change Model (Kettinger, 1997)
Figure 1. Business Process Change Model
(Adapted from Kettinger and Grover 1995)