Building Customization Capability

by

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ABSTRACT

Many computer companies are seeking to grow their customization capability. As the market becomes increasingly commoditized, computer companies view customization as a way to differentiate their products and offer customer value. However, the implementation of customization programs has been difficult for many organizations.

Sun Microsystems launched a customization program called Customer Ready Systems (CRS) through a grass-roots effort in manufacturing. CRS offered assemble-to-order, factory-integrated systems. Although CRS revenues had been growing, scalability was difficult and costs were increasing. CRS needed to evaluate its process and supply-chain from a strategic perspective to ensure alignment with the rest of the organization. To grow profitably, it also needed to reduce costs and increase scalability.

This thesis focuses first on the question of whether or not Sun should reconfigure its supply chain to perform more, if not all, of its customization work at external manufacturers. It then turns to the question of whether or not the current internal customization process can be improved, and identifies two opportunities: pricing and process improvement in component removal for reconfiguration, and lead-time variability reduction. This thesis recommends organizational and tactical policies to improve the customization based on these analyses and implementation efforts.

The research for this thesis was conducted during a seven month internship with Sun Microsystems’ Worldwide Operations group and was affiliated with the Massachusetts Institute of Technology’s Leaders for Manufacturing program.

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1 INTRODUCTION

1.1 Customization in the Computer Industry

The evolution of the computer industry was arguably one of the most important developments of the twentieth century. Moore’s law, which states that the number of transistors per square inch of integrated circuits will continue to double annually, implies that the pace of technology change makes fundamental shifts in the industry possible in the span of years versus decades in other industries. This was evident in the last twenty years, where the competitive landscape shifted from one dominated by few, vertically integrated players to one with numerous players competing horizontally building modular components and peripheral products.¹

Currently, the computer industry is characterized by intense competition, modular designs, and short product lifecycles. Small, focused technology companies have been able to carve out niche markets and compete effectively against large, vertically integrated companies. Efficiency in information transfer, reduction of transportation costs, and learning in developing countries have also resulted in the growth of many low cost technology companies from developing countries.

The maturation of the computer industry has led to increased commoditization and lower prices. Many companies needed to adapt their operations strategies to reduce costs and stay competitive. Large computer companies outsourced most component manufacturing to gain cost advantage. For example, the current industry leader Dell only conducts final assembly in its factories. Dell used its tight operations and supply chain efficiency as sources of competitive advantage.

The success of Dell’s direct sales, mass customization business model illustrated that cost leadership was possible even in a customization environment. Dell’s model reduced inventory risk caused by short product lifecycles and uncertain demand by delaying final

assembly until after the customer ordered. Dell’s direct sales could also be differentiated against the channel strategies followed by most of its competitors, and its success encouraged many of its competitors to follow by offering customized products through their own direct sales channels.\(^2\)

However, the transition for many companies to offer customized products through direct sales was not met with enormous success. First, many companies depended on their channel partners for relationships with end customers, and risked alienating their channel partners by increasing direct sales. For example, “Compaq and HP talked a lot about doing it Dell’s way but couldn’t bear the pain of burning their retail channel.”\(^3\) Sun and Cisco “depend too much on their reseller and consultant network to go fully direct – and innovate too much to abandon forecasting entirely.”\(^4\)

Second, execution of a customization strategy was made more difficult when customization was not considered during the product development process. Configurable options are more easily added to modular products designed for quick assembly and customization compared to integral products not designed to change. This can also be extended to designing for integration; a server designed for optimal performance as a standalone unit may not be optimal when racked with several other servers and storage units.\(^5\) Customization and integration considerations should be made in the product design rather than after manufacturing.

Finally, outsourcing manufacturing to overseas companies for cost advantage led to higher transportation costs. Using lower cost transit modes and capturing transportation economies of scale became essential to maintaining low costs but also led to extended lead-times. These long lead-times, coupled with uncertain demand, led to high inventory

\(^4\) Ibid.
and obsolescence costs when used with traditional inventory policies and build-to-stock models. Many companies responded by developing delayed differentiation or postponement models.

Despite these challenges, many computer companies are seeking to grow customization capability. As the computer industry continues to mature, companies must seek new ways to differentiate their products. Six Sigma and other quality initiatives focus on “delighting the customer”; customization is seen as one way means that a company can add value to customers. An efficient customization program enables a company to delight customers by giving them what they want and to collect customer information that can be used to develop new products.

1.2 Operations Strategy and Customization at Sun

Sun Microsystems is a computer company focused on network computing products. The company vision, “everyone and everything connected to the network,”\(^6\) defines Sun’s core mission: to provide an infrastructure of scalable and reliable systems required to support network computing. Sun’s products include network storage systems and high volume computer systems such as servers, UltraSPARC microprocessors, desktops, and workstations. Sun also offers enterprise infrastructure, development software, and professional and educational services. Figure 1.1 illustrates a high level overview of Sun’s product lines.

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\(^6\) http://www.sun.com
Sun had approximately $11.4 billion in net revenues during fiscal year 2003, compared to $12.5 billion in 2002 and $18.3 billion in 2001. Revenue declines reflect the economic downturn. Sun is also being pressed by its competitors (IBM, HP, Dell), and lost 4% market share in servers between 2002 and 2003.

Sun is a matrixed organization; employees belong to central functional groups such as Operations, Sales, or Marketing, but work on specific vertical business units that support individual product lines (see Figure 1.2).

Sun's competes on product differentiation through technology innovation in end-to-end network computing systems. In order to execute on its differentiation strategy, Sun

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7 This chart has been generated for clarification purposes for this thesis only, and does not represent Sun's actual product line categorization or organizational structure.
invests heavily in research and development. In 2003, Sun invested about 16% of its revenue in R&D expenses, compared to 1-1.5% for Dell and 5% of HP, for example.  

Sun conducts a significant percentage of its business through value-added resellers, channel development providers, system integrators, and independent distributors. It sells directly only to large corporate customers. In the past few years, Sun sought to reduce costs by reducing the number of system configurations and increasing standardization to simplify manufacturing processes.  

In 2003, Sun had three manufacturing facilities in California, Oregon, and Scotland, and three distribution centers, in California, the Netherlands, and Japan. In 2004, Sun was seeking to transform its fulfillment model from centralized distribution centers to a direct ship and cross-dock model. Sun also announced manufacturing consolidation and began to move its California manufacturing operations to Oregon and Scotland. These decisions were made to reduce cost and inventory risk, and supported Sun’s overall strategy of focusing on product development while partnering with external manufacturers and channel partners for manufacturing and distribution.

All Sun volume servers and some network storage were externally manufactured and built-to-stock with push supply chains. Sun also sole sourced the manufacturing of integral components such as SPARC microprocessors. Generally, production requirements for all products were set in advance based on forecasted supply plans. In some cases, Sun used min-max models to determine the optimal inventory levels in its distribution centers. However, many suppliers operated under Sun’s demand replenishment program that required short replenishment lead-times. These suppliers had product hubs located near Sun’s distribution centers. Theoretically, no safety stock existed for these products in Sun’s distribution centers.  

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8 Sun suffered lower revenues in 2003; historically, it spends about 10% of net revenue on R&D.  
10 Charles A. Holloway and others. “Supplier Management at Sun Microsystems (A): Managing the Supplier Relationship.” Stanford University Graduate School of Business, Case # OIT-16A.
In order to limit the inventory risk of its push supply chain for volume products, Sun limited the number of configurations offered to three standard configurations: small, medium, or large. Options such as additional memory, PCI cards, and graphics cards that could be added to these configurations were sold separately. These options were sometimes standardized across product lines, therefore enabling aggregation of options for supply planning. Despite these policies, inventory obsolescence continued to be a challenge requiring careful management, not only of Sun’s internal inventory, but also in the inventory held by its downstream channel partners.

Sun’s volume server group offered some customization among low-end servers through its external manufacturers in its external assemble-to-order (XATO) program. Customers could select the processor size, memory size, disk drives, and operating system from a list of available options rather than ordering a predetermined small, medium, or large configuration. In general, these customized servers had higher prices and longer lead times than the standard configurations, and represented a small percentage of total sales.

Sun’s enterprise servers are high-end servers with more than eight processors. These servers often contain racked storage units. Enterprise servers were all manufactured internally using an assemble-to-order, or pull, model. Sun pulled the customer-specified components out of kanban bins and performed final integration after receiving the customer order. This supply chain was a push-pull system; building blocks were built-to-stock and stored in supplier hubs, at the Sun distribution center, or in the Sun factory, and pulled to customer order after the order booked. The point where the generic building blocks become part of a customer order, or the push-pull boundary, was located at Sun.

Sun’s network storage products were manufactured either internally or by external manufacturers, depending on the product line. Historically, network storage products were all built-to-stock, like the volume servers. More recently, Network Storage operations was using assemble-to-order models for the higher end, internally
manufactured storage products.

Because product lines were organized vertically, customers could not order integrated Sun products (e.g., volume servers racked on a network storage unit) through Sun directly. Instead, they had to order the systems separately and integrate the systems on their own site using either Sun Professional services or a third-party system integrator. In 2002, Sun launched the Customer Ready Systems (CRS) program to provide systems integration capability across product lines and services. This program offered factory-integrated systems comprised of Sun and third-party hardware and software directly to large corporate customers.

1.3 Sun’s Customer Ready Systems Program

CRS began as a grass-roots effort within Sun’s Enterprise and Network Storage units. Previously, large corporate customers who ordered Sun products spanning different product groups received hundreds of separate boxes and needed to allocate facility space, internal resources, and Sun services personnel to integrate these systems. Because this integration was performed on customer sites often without ESD protection, the integration sometimes damaged the products. Further, many Sun products were developed independently, without high consideration placed on integration with other Sun products. These design limitations caused difficulty during integration. As a result, customers desiring integrated systems of Sun products had the perception that Sun products were poor quality.

Members of Sun’s Enterprise and Network Storage units realized that the customization being done at customer sites should be done at the Sun factory, with trained personnel and the appropriate materials, safety, tools, and testing infrastructure. As a result, as a sort of pilot, or experiment, the operations program manager offered to perform factory integration for one key corporate customer. This offer was accepted, and the delivered solution dramatically exceeded the customer’s expectations, thus setting the precedent for more factory-integrated systems and the launch of CRS.
CRS systems are assembled-to-order, tested in Sun factories, and shipped to customers in a minimal number of boxes ready to deploy without additional time-consuming and expensive customization and configuration. CRS revenues have been growing, and CRS has been identified as an area of development by Sun’s executive management.

Figure 1.3 illustrates how CRS fits into the rest of Sun. Organizationally, CRS is shared by Sun’s Enterprise and Services business units. However, CRS uses products from all of Sun’s hardware and software business units. A separate operations group exists for CRS responsible for the manufacturing and fulfillment of CRS orders. Although Operations is a centralized functional group at Sun, people working within Operations are allocated to support specific business units. Therefore, the Operations group for CRS operates relatively independently of the other operations groups.

This thesis is based on research conducted during a seven-month internship in the CRS Operations group. It evaluates Sun’s implementation of customization through CRS and discusses the challenges involved in growing mass customization capability. Chapter 2 describes Sun’s Customer Ready Systems program in more detail and the operations and
supply chain challenges faced by the CRS Operations group. Chapter 3 describes the results of an analysis conducted to determine where customization should begin in the supply chain for integrated products. Chapters 4 and 5 describe related analyses and improvement activities completed. Chapter 6 describes the challenges associated with implementing the process change. Chapter 7 concludes with thoughts to bear in mind when launching a customization strategy and offers suggestions for future projects.
2 CHALLENGES FACED BY CRS

2.1 CRS Supply Chain and Problem Statement

Figure 2.1 shows the CRS supply chain for 2003. (CRS is represented as the “Sun Factory – Custom Systems.”) CRS Suppliers include all existing Sun and some additional third party suppliers. Sun suppliers include commodities and options suppliers for components such as memory, hard drives, and PCI cards; and the contract manufacturers of volume servers and storage. All Sun standard products (used as building blocks for the custom systems) are pulled from the distribution center, while unique third party parts are shipped directly to the factory. Depending on the timing and order, CRS solutions are either shipped directly to the customer from the factory, or shipped back to the distribution center. Although historically in the US CRS customers have been large, corporate customers, CRS can also provide solutions to Resellers.

Figure 2.1: Sun’s CRS Supply Chain (US)

Sun is transforming its fulfillment network in the United States from one with centralized distribution center to a cross-docking model in 2004. Under the cross-dock model, no
finished goods inventory will be stored at the cross-dock; Sun suppliers will hold most finished goods inventory and, whenever possible, ship directly to Resellers or End Customers. The cross-dock is a location for order aggregation when necessary rather than for warehousing; any product coming into the cross-dock is already allocated for a customer order. The implication for CRS is that the inventory of standard systems from which it draws today will now be located at the suppliers of those systems.

The CRS supply chain is a push-pull system (see Figure 2.2). Sun standard components are built-to-stock, and demand forecasts are aggregated across all product lines. When a CRS order books, standard components are pulled from the distribution center into the Sun factory. The solution is then customized and integrated to order, tested, and shipped.

**Figure 2.2: CRS Push-Pull Boundary**

<table>
<thead>
<tr>
<th>Push Boundary</th>
<th>Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push</td>
<td>Pull</td>
</tr>
<tr>
<td>Suppliers</td>
<td>Customers</td>
</tr>
<tr>
<td>Standard systems are built to stock based on forecast from Product Groups</td>
<td>Standard systems are pulled from stock and integrated to order through CRS</td>
</tr>
</tbody>
</table>

**Differentiation Point: Sun Factory**

Most of the solutions built by CRS involve volume servers integrated with storage units. Many volume servers could also be individually customized with configurable options; that is, customers can add additional memory, hard drives, or PCI cards. CRS was considering using Sun’s external manufacturers for some of the volume server customization, thereby moving the push-pull boundary to the external manufacturer. Customized boxes would be pulled into the factory for final integration. The implications of this change needed to be understood for both CRS and for Sun as a whole.
CRS wanted to determine the optimal process balance between customization done at Sun external manufacturers and that done at Sun. However, analyzing this question revealed other questions and improvement opportunities that could be analyzed to increase the customization capability. As a result, a more generic project goal was defined. This thesis seeks to evaluate the CRS customization process, identify areas for analysis and improvement, reflect on implementation efforts, and make some recommendations for other organizations seeking to build customization capability.

2.2 Existing CRS Challenges

Existing CRS challenges were identified through interviews with CRS personnel and the Sun groups with which they interfaced. These challenges, like most supply chain pitfalls, arose from lack of information, operational problems, and strategic and design-related issues.¹¹

First, inventory visibility was poor. CRS had little visibility into available inventory, and thus had difficulty predicting customer lead-times. Analogously, product groups had little visibility into CRS demand. At an aggregate level, CRS orders represented a small percentage of the total product demand for any given product line, so CRS did not alter the aggregate product forecasts from a supply planning perspective. However, individual CRS orders were often for large quantities, and thus could theoretically trigger temporary inventory shortages.

CRS solutions were also highly complex; because of the high number of options, configurations, and engineering rules, they could not be custom designed by the customer from a website (as Dell desktops can). CRS customer program managers and engineers were required to work with sales account teams and customers to ensure that all the requirements of the integrated solution were fully defined, and that the resulting solution would be functional. The actual order-entry process was therefore time-consuming, required numerous resources, and limited the program’s ability to scale.

CRS also did not have direct relationships with its suppliers; it worked through other Sun product groups that owned the supplier relationships to obtain material. There were no formal processes in place for CRS to procure materials, which resulted in “discrimination against internal customers.” A system glitch treated materials transfers between CRS and the product groups as internal transfers, which had a lower priority than other customer orders. CRS supply managers relied, instead, on informal processes to secure material to build CRS orders within reasonable lead-times.

Using finished goods from product groups also resulted in excessive waste. Finished goods were fully labeled in expensive packaging with manuals. CRS customers often ordered many servers on a rack, and did not need all the packaging and manuals for each individual server. The excess packaging and manuals needed to be returned or recycled at cost to Sun. Further, CRS orders comprising only box-level reconfigurations could have been customized by the original manufacturer of these servers, but instead were routed through the Sun factory. Many of these orders had relatively high volumes of the same customized configuration. In most cases, CRS had to remove components from the standard systems and add other components according to the customer need.

Finally, most of Sun’s Volume Server products (the primary feeders to CRS) operated under a standard configuration strategy, providing only three configurations per product, and driving operations around low cost. CRS, on the other hand, provided high-quality, integrated solutions developed specifically for individual customers. This required scalability and customer satisfaction, but not necessarily a low-cost, efficient supply chain. This misalignment caused some product groups to be slow to invest in projects or to adopt processes that supported the CRS customization business, even when their support may have been more efficient to Sun overall.

2.3 Approach

One of the original drivers of this project was to present a data-driven analysis of
outsourcing that considered all the variables and presented an analytical answer to the question of how much customization ought to be done where in the supply chain. Previous attempts had been made to outsource some customization to suppliers for CRS, but had not been fully implemented because of the lack of data to support the business case.

This research was divided into two sequential parts: Customization Analysis and Implementation. The analysis portion sought to answer where customization should begin theoretically in the CRS supply chain. The existing process (no supplier customization) was evaluated against two alternatives both involving some level of supplier customization on the basis of cost, quality, and lead-time using data from historical orders, forecasted supply plans, defect reports, and interviews with operations, manufacturing, and supplier managers. This analysis was conducted for both the existing supply chain (with a local distribution center) and for the future state with the local distribution acting as a cross-dock rather than storage location. This analysis also sought to uncover other sources of opportunity and improvement in the customization process and supply chain.

The implementation portion focused on recommendations made from the analysis phase. This included continuous improvement work on existing process, additional investigation of CRS lead-times, and pilot development for integrating customized products into larger CRS solutions. In any implementation effort, alternatives need to be brainstormed and evaluated based on the impact to the existing business processes and systems. Any business and IT changes required were documented and approved through work with business process analysts, IT personnel, and product line managers. Organization challenges were also documented and some suggestions were made for building customization capability in any organization.

12 Ibid.
3 Evaluation of CRS Customization Process

3.1 CRS Products and Manufacturing Process

CRS solutions fall into two product lines: standard products and specialized products. These two product categories require separate order entry systems, processes, and pricing.

Standard CRS solutions comprise of only Sun standard products. Factory integration involves adding custom options, racking, and cabling. Most of the solutions are Integrated Solutions – Enterprise or Volume System Products (VSP) servers customized with hardware options and then integrated with Network Storage units. VSP servers are either low-end (two or fewer processors) or mid-range (four or eight processors). Integration for these Integrated Solutions often involves racking and cabling. Some standard CRS solutions are simply customized mid-range VSP servers, with no further integration with other systems. Customization entailed adding, removing, or replacing hardware components on the servers. These are called Single Boxes.

Specialized CRS solutions involve more specialized customization, such as third party hardware, custom software download, or hardware removal (e.g. removing memory from a Sun VSP server). Like the Standard CRS solutions, Specialized CRS solutions are mostly Integrated Solutions – customized VSP servers racked or cabled with Storage units. However, Specialized CRS solutions also have many often Single Box solutions. These include both low-end and mid-range VSP servers customized with some third party parts and/or requiring hardware removal. The table in Figure 3.1 shows the CRS product types with their potential components.
The two CRS product types are manufactured on separate lines using separate processes. However, at a high-level, the manufacturing process and supply-chain are the same (see Figure 3.2 for the standard process). Solution components are pulled from the distribution center into the factory; any customization at the box-level is completed, and then the customized servers are integrated with the other systems for the customer solution. After the cross-dock is implemented, it is expected that suppliers will ship CRS materials directly to the factory (rather than through the cross-dock).
Future Cross-Dock (Direct-Ship) Process

3.2 CRS Demand

Figure 3.3 shows the shape of CRS orders for fiscal year 2003. Orders grew linearly with some end-of-quarter seasonality in the first, third, and fourth quarters. Linear growth could be attributed to gradual increased marketing, resources, and scale in the program. Seasonality may have been caused by promotions and other sales incentives used to meet end of quarter targets as well as customers who preferred delaying purchases until the end of the quarter.

Figure 3.3: Weekly CRS Orders for Fiscal Year 2003

After accounting for the linear growth trend, the coefficient of variation\(^{13}\) is 0.69, implying that although the data is dispersed, there is some order predictability. However, CRS orders were comprised of over 20 different servers and hundreds of custom options.

\(^{13}\) Coefficient of variation = Standard Deviation / Mean, and measures relative spread around the mean.
Although the aggregate number of orders may be predictable, demand for individual orders are not. Figure 3.4 shows the percentage of total orders that included the top five servers ordered in 2003 by quarter. The relative popularity of these servers ordered through CRS in 2003 changed by quarter, sometimes significantly. For example, Product 2 represented only 5% of total orders in the first quarter, but over 35% in the fourth quarter. Large orders from individual customers could cause unpredictable shifts in demand for specific products. The high number of product offerings, the relatively low volume through the CRS program, and short product lifecycles

Figure 3.4: Quarterly CRS Product Mix for Top Five Product Lines

3.3 Analytical Framework

All CRS customization work took place in the Sun factory and was done by CRS personnel. CRS, however, wanted to evaluate the option of using the assemble-to-order process (XATO) offered by VSP low-end external manufacturers, but needed to understand the implications of making the change. The approach followed to frame the analysis was:

(1) Identify the customization options to be evaluated
(2) Identify the relevant evaluation criteria through interviews with CRS personnel
(3) Determine how to measure the relevant criteria
(4) Collect the data required for measurement
(5) Measure the results of each alternative

Three customization alternatives were evaluated (See Figure 3.5):

(1) **Alternative 1 (Status Quo): Customize Internally** - Standard servers are built to stock by the Supplier and then shipped (presently via the distribution center) to the Sun factory, where factory personnel customize and integrate the servers to customer order. This represents the existing strategy.

(2) **Alternative 2: Reconfigure Externally** – Suppliers build standard products to stock, but these standard products are then customized at the Supplier site to customer order. This implies that standard boxes would still need to be disassembled for reconfiguration. The Sun Factory conducts final integration of these customized servers for integrated systems, but single boxes would be shipped directly to the customer (presently via the distribution center).

(3) **Alternative 3: ATO Externally** – Suppliers assemble boxes to customer order at the Supplier site. This implies that any server requiring customization would be built as a custom system. Thus, no reconfiguration of already built systems would be needed. The Sun Factory conducts final integration of these customized servers.

*Figure 3.5: Three Customization Alternatives Evaluated for CRS Supply Chain*
Alternative 2: Reconfigure Externally

Alternative 3: ATO Externally

CRS was not seeking to outsource final integration to an external manufacturer; therefore, all integrated solutions still had final assembly at the Sun factory. Single Box solutions could be shipped (presently through the DC) to CRS customers under Alternatives 2 and 3 without needing to pass through the Sun factory.

CRS personnel agreed that quality, lead-time, and cost were the critical factors that needed to be measured for each alternative. Each alternative was measured on Quality, Lead-Time, and Cost for both the existing supply chain (distribution center acts as a warehouse) and the future supply chain (cross-dock); and for Single Boxes and Integrated Solutions. Figure 3.6 summarizes the scenarios evaluated.
3.4 Quality Results

Customizing a server in the Sun factory involved opening the server chassis, adding/removing/changing the relevant parts, and closing the chassis. Most people believed that this customization increased the defect rate of solutions shipped to customers relative to that for systems that were not reconfigured after they were built. Further, they believed that if this rework could be eliminated, the defect rate should decrease. The hypothesis was that using a supplier’s assemble-to-order process (Alternative 3) would have the least amount of rework and would therefore result in the highest quality.

However, this effect was not actually measurable because testing conditions differed between CRS and the external suppliers. A VSP server might pass all the testing required by the Product Group at the supplier, but after sitting in stock at the supplier and Sun’s warehouse for some time, the server might, upon arrival at the CRS factory, fail its “cold start.” If a “cold start” of that server failed, CRS would label it as defective, return it to the VSP Product Group, and pull another server out of stock. Often, these “cold start” failures could not be replicated; the server would start successfully on subsequent attempts. In the field, however, a server that failed its “cold start,” but then started successfully later might not be reported or returned by Sun services personnel or the customer.

This behavior led to a difference in reported defect rate. Figure 3.7 shows the defect rates
reported as “Dead on Arrival (DOA)” by the VSP Product Group and by CRS. As shown in the figure, DOA rates reported by Product Groups were orders of magnitude smaller than those reported by CRS.

**Figure 3.7: DOA reported by VSP and seen by CRS for 9 product lines.**

This discrepancy occurred because Product Groups were responsible for keeping their defect rates and costs low, but CRS had no incentive to accept quality risks for their customers, especially since they could immediately pull replacement parts from the Sun distribution center. CRS also had more stringent pass criteria and longer test times on integrated solutions, so their customers had a statistically significant reduction in the number of “Early-Life Failure” issues relative to most other Sun customers. Although the CRS DOA rate was beginning to be used as the standard proxy for actual customer defect rate, there was still internal disagreement as to whether or not what CRS labeled as defective was truly defective.

CRS did not trust the quality of any system pulled from the distribution center; therefore, all CRS solutions underwent the same extensive testing process. Because testing should have been consistent (among the various alternatives considered), CRS customers should have seen the same defect rate regardless of the source of customization. As long as the
sources of defects from external factors, such as transportation, were consistent regardless of scenario, quality measured as customer defect rate should have been the same across all the alternatives considered.

However, even though the customer defect rate should have been the same, by outsourcing part of the customization, the expected number of defects introduced by CRS should have decreased, simply because CRS would be doing less work (thus transferring the risk of defects to its suppliers). Therefore, the cost of defects to Sun should have been lower. Alternatives 2 and 3 both used Suppliers rather than CRS to reconfigure the servers; therefore, the expected decrease in defects introduced by CRS should have been approximately equal to the historic defect rate of CRS defects introduced during server reconfiguration.

To estimate this value, quality reports from 2003 were evaluated, and all defects introduced by Sun during the server customization process were counted. No functional defects were introduced by Sun during box customization, and the rate of non-functional defects (e.g. a scratched box) was also insignificant. Thus, we could assume that there would be no significant reduction in costs from defects from any alternative.

For the Single Box case, the supplier would have end-to-end control of the customization. However, as discussed above, the testing conditions would be different. Currently, CRS tests servers as “cold starts.” This would be difficult to replicate in an assemble-to-order process. CRS believed that the true quality metric, customer defect rate, would have been higher unless the external manufacturer could mimic the existing CRS testing exactly, which they could not do unless they followed the existing CRS process (pull a server from the Sun warehouse and reconfigure it).

As a result, quality was not a driving factor in this decision. CRS was only seeking to outsource box-level customization, retaining more complex cabling and racking capability internally. Because this work was less complex than other operations, the risk
of introducing defects through box customization was small, especially among trained personnel. Further, even if these defect rates were high, outsourcing to decrease defect rates may be a case of getting “rid of problem a company hasn’t been able to solve itself,”\(^{14}\) and may not have been appropriate if Sun wanted to grow its customization capability. Finally, defects seemed to arise more from design flaws (narrow tolerances, excessive heat when racked on a storage unit, etc.) rather than from the final assembly of the boxes. CRS and Sun may have more success decreasing defects by designing products with integration in mind.

3.5 Lead-time Results

Lead-time for this evaluation was defined as the “Book-to-Ship” time, or the time between the customer booking the order and that order shipping to the customer. Assumptions for this analysis were:

- Assembly and test time were the same for standard products and for customized products (ATOs) at the suppliers
- As long as the distribution center acted as a warehouse, CRS could pull a standard configuration out of stock; no shortages or stop ships were in effect

Currently, CRS pulls standard configurations from the local Distribution Center (DC) and then follows the existing factory process as shown before in Figure 3.3. The total lead-time is transportation time from the DC + total factory cycle time.

Alternative 2 more or less replicates Alternative 1 in terms of process steps, but the lead-time is longer. Although the actual customization of a server takes only minutes, if the supplier performs customization, the supplier will have to unpack and repack the servers (steps that will in effect be duplicated at the CRS factory) and may have to retest the units after customisation. The total lead-time for Alternative 2 is therefore the extra supplier overhead time for customization + transportation from the supplier to CRS + total factory cycle time.

Alternative 3 involved assembling the system to order at the supplier. The total lead-time from a customer point of view would be the time to assemble the system + transportation from the supplier to CRS + total factory cycle time. Figure 3.8 summarizes the results for the distribution center case.

Figure 3.8: Theoretical Lead-Time Differentials, DC case

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Lead Time Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit from DC</td>
<td>Factory cycle time</td>
</tr>
<tr>
<td>Alternative 1</td>
<td>1 to 5 days</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>1 to 7 days</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>1 to 7 days</td>
</tr>
</tbody>
</table>

As shown in the Figure 3.8, the current case offers the shortest theoretical lead-time. Alternative 2 adds 1 – 5 days, depending on the supplier location. Alternative 3 adds 1 – 7 days depending on the supplier location and the complexity in assembling the server. For example, mid-range servers are manufactured on the East Coast and take at least 3 days to assemble and test. Therefore, using an assemble-to-order process for mid-range servers would prolong theoretical lead-time by 7 days, unless alternate transportation modes are used. However, some low-end servers are manufactured a twenty-minute drive from the Sun factory, and take less than 1 day to assemble and test. Using an assemble-to-order process for these servers would only extend lead-time by 1 day.

Figure 3.9 shows the theoretical lead-time differentials for the future cross-dock scenario. In this scenario, the transportation advantage caused by the local distribution center from Alternative 1 disappears. Therefore, theoretical lead-time differentials shrink to just 1 day for Alternative 2 and 1-3 days for Alternative 3 (depending on the assembly and test time).
Figure 3.9: Theoretical Lead-Time Differentials, Cross-Dock Case

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Lead Time</th>
<th>Lead Time Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>Transit from Supplier, factory cycle time</td>
<td>1 day</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>Customization overhead time (1 day)</td>
<td>1 day</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>Assemble-to-Order time (1 to 3 days)</td>
<td>1 day</td>
</tr>
</tbody>
</table>

For the Single Box case, servers could be customized and direct-shipped or built, tested, and direct shipped from the supplier to the end customer. Figure 3.10 summarizes the theoretical lead-times of the three alternatives. In this case, Alternative 1 would have the longest lead-time and Alternative 2 the shortest. However, the testing conditions under Alternatives 1 and 2 differ. As mentioned earlier, CRS tests all solutions that come through the factory, sometimes for 48 hours. If the supplier were also to perform an extensive retest after customizing, Alternative 1 would only be slower by 1 day (the transit time from DC to factory).

Figure 3.10: Theoretical Lead-Times, Single-Box Case (Direct-Ship to Customer)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Lead Time</th>
<th>Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>Transit from DC, factory cycle time (1 day)</td>
<td>2 to 4 days</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>Customization overhead time (1 day)</td>
<td>1 day</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>Assemble-to-Order time (1 to 3 days)</td>
<td>1 to 3 days</td>
</tr>
</tbody>
</table>

The analysis illustrates the impact of assembly time, supplier locations, and transportation time on customization strategy. Theoretically, the lead-time differential of integrated solutions depends on the time to build or customize the product and to ship it to the factory. Using the local suppliers for customization of low-end servers would not impact lead-time considerably, but using suppliers on the opposite coast for the mid-range servers would cause more significant increases, especially if these servers are assembled-to-order. After the cross-dock is implemented, the lead-time differential for
integrated solutions only depends on the time to build the product. Single boxes that can be direct-shipped to the customer from the supplier would have shorter lead-times.

This analysis also illustrates the need for an organization to be able to assess new supply chain configurations regularly as things change. When a company chooses to move or consolidate a facility for cost benefits or strategic reasons, it needs to consider how the supply chain will be impacted and assess whether a new supply chain configuration might be optimal. For example, in 2004, Sun intends to close of its California manufacturing facility and eliminate the California distribution center as a stocking location. A low-end server supplier customization strategy that may have made sense under the existing configuration would need to be reevaluated under the new configuration. Any customization strategy should be flexible enough that it does not lock an organization into one specific supply chain configuration.

Lead-time analyses should also be conducted with customer value in mind. Currently, CRS dictates lead-times to customers. Although customer program managers believe that in some cases the lead-times are too long, they do not know the optimal lead-time to satisfy customers or to grow revenue. Many believe that it is more important to maintain integrity between promised delivery date and actual ship date; completed solutions that are built ahead of schedule sometimes wait in the distribution center until the originally promised ship date. The impacts of shortening or lengthening lead-times are unknown, which leads to uncertainty on how relative differences in lead-time should impact decision-making.

Finally, this lead-time analysis was conducted based on theoretical lead-time capability of suppliers and Sun. Some doubt existed as to whether solutions could be delivered against these theoretical best values. A later study, presented in Chapter 5, analyzed the actual CRS lead-times and discovered discrepancies between actual lead-times and these theoretical approximations.

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3.6 Cost

The goal of the cost analysis was to compare the total cost to Sun of the three alternatives. Relevant costs included labor, transportation, inventory, and implementation.

3.6.1 Labor Cost

Indirect labor was assumed to be the same under all strategies. The total direct labor cost of the existing strategy could be broken down into the suppliers’ direct labor costs and Sun’s direct labor cost. Because Sun’s direct labor force was fairly flexible, all outsourced customization would decrease Sun’s labor costs.

Alternative 2 involved moving customization from Sun to the supplier. In the worst case, this strategy requires the supplier to unpack and repack finished goods held in its own warehouse (denoted below as Customization Overhead). Therefore, the total labor cost savings for integrated systems would be:

\[
\text{Average Time to Customize a Box + Customization Overhead} \times (\text{Sun Hourly Loaded Labor Cost} - \text{Supplier Hourly Loaded Labor Cost}) \times \text{Total Expected Boxes to be Customized.}
\]

Alternative 3 used the supplier’s assemble-to-order process. Interviews with suppliers and operations program managers revealed that the direct labor time required to build a standard configuration was roughly the same as the time required to build a custom configuration. This was because adding configurable options while the server was being built did not take that much time. There would be no extra supplier labor costs in this case, so the total labor cost savings for integrated systems would be:

\[
\text{Average Time to Customize a Box} \times (\text{Sun Hourly Loaded Labor Cost}) \times \text{Total Expected Boxes to be Reconfigured}
\]

Labor cost savings for Single Boxes would be much higher; because the Sun factory could be avoided entirely, labor time from kitting and packout could be avoided completely. Although the direct labor time to customize a server is on the order of
minutes, the direct labor time for the entire process (excluding test) is on the order of hours. Total labor cost savings would be:

\[
\text{Total labor cost savings} = \left( \text{Average Time to Customize a Box (Hours)} + \text{Sun Factory Customization Overhead} \right) \times \text{(Sun Hourly Loaded Labor Cost)} \times \text{Total Expected Single Boxes}
\]

These calculations had some caveats. First, many supplier contracts did not have a labor rate or labor costs listed explicitly. Although the overall cost structure at the supplier should have been lower than Sun’s cost structure, if the labor rate was not broken out explicitly, calculating labor cost savings was imprecise. Further, for some of the low-end servers, the existing contract had a more expensive pricing structure for custom configurations as opposed to standard configurations, even though the standard and custom configurations used the same parts and testing infrastructure. Although these costs were slated to be negotiated out of future contracts, they did exist in the current state.

Despite these caveats, this analysis concluded that labor cost savings from outsourcing increased linearly with volume, and was higher for Alternative 3 than for Alternative 2. At the existing volume, total annual labor cost savings for Alternative 3 (having the supplier perform all customization work) would have been less than half a million dollars. Alternative 2 would have been comparable to Alternative 1, the existing case.

The calculation for single boxes was the same, except that the labor cost of the Sun factory was avoided entirely. This amounted to under a hundred thousand dollars for the existing volume. Note that single boxes had lower volume overall relative to the program size.

**3.6.2 Transportation Cost**

In the existing structure, many of Sun’s suppliers did not make daily shipments to Sun’s factory or distribution center. Therefore, for integrated systems, if the custom configurations needed to be shipped immediately to the Sun factory for further integration, transportation costs may have been higher because of potential expedited
shipping and lack of economies of scale. For mid-range servers, if the servers used overnight shipping at the current UPS rate, the transportation cost of the alternatives would have added less than 5% to the total product cost, and have been on the order of magnitude of ten thousand dollars total for the year. This is the case for both Alternatives 2 and 3.

For single boxes, no additional transportation costs are incurred because the boxes can be direct-shipped from the supplier. No transportation costs savings are incurred either, because factory shipments are currently consolidated at the distribution center.

In the future cross-dock scenario, no differences would arise from transportation costs of integrated systems because all products would be direct shipped from the suppliers. Transportation costs of Single Boxes would be less expensive under Alternatives 2 and 3, because shipping to the factory would be unnecessary. This savings was on the order of magnitude of thousands of dollars for the year.

3.6.3 Inventory Cost

Currently, low-end servers already had the XATO process in place, so integrating it with CRS would not have resulted in any increased inventory costs. However, because mid-range servers did not have XATO, operations managers believed that implementing it would require stocking configurable options at the supplier and increase inventory costs.

Determining the correct amount of inventory to hold at the external manufacturer of mid-range systems was difficult. Although the top 5 options (20%) represent nearly 80% of total demand for options (see Figure 3.11), the other options were still offered. Figure 3.12 shows how the weekly demand for these options was highly variable. Given this options proliferation and demand pattern, traditional min-max inventory models would have yielded unsatisfactory results. To illustrate this, a standard min-max model was constructed from one year’s worth of data to approximate the inventory levels needed for service levels between 90% - 99% (See Appendix 1 for Model Details).
Product lifecycles were relatively short for the options (less than two years), so inventory also increased the risk for obsolescence. For this model, the maximum cost of obsolescence was estimated to be the cost of the Maximum Inventory (the Inventory Cost of the Order-Up-To-Amount multiplied by the Salvage Value) multiplied by some risk.
factor. From interviews with operations programs managers, this risk factor should have been zero if the Product End of Life process was handled well. However, historically, some expensive oversights had been made in this area.

From the model, inventory costs were not high relative to other costs (thousands of dollars per year), but the largest cost driver was the risk factor selected for managing product end-of-life (zero to hundreds of thousands of dollars per year). This model was then tested against the actual demand of Q1 2004. Despite the 95% service level targeted, there would have been stockouts for 20% of the orders in Q1 2004. Further, there would have been zero demand for 40% of the options for which inventory was kept. This inventory policy was completely inappropriate for these products. Given the relatively light weight of these options, overnight shipping from the Sun distribution center or the supplier directly without increasing inventory held would have been much more appropriate. By reducing lead-time and instituting a more flexible inventory policy, the costs and inventory risk could be reduced dramatically.

This analysis emphasized the importance of managing the product end-of-life process as well as selecting the correct inventory policy based on the demand pattern. For mid-range servers, a standard inventory policy for the options could not be used for an assemble-to-order process. The inventory cost of options could be significantly reduced by instituting more flexible options, such as air-shipping options from the supplier or the Sun distribution center.

3.6.4 Implementation Cost
As mentioned previously, many low-end server product lines already had an External Assemble-to-Order (XATO) process in place at the supplier. Mid-range servers had XATO processes for previous products, so the supplier already had the IT infrastructure to implement an Assemble-to-Order process. The cost of implementing Alternative 3 (ATO externally) would simply be the IT cost of integrating the existing XATO process with CRS. This required an IT change to the Sun ERP system to enable hierarchy in the Bill of Material (BOM) structure. IT personnel were consulted to estimate the cost of this
change, which was less than a hundred thousand dollars.

3.7 Summary, Other Considerations, and Recommendations

Figure 3.13 summarizes the order of magnitude of the costs. Although the business case was stronger for customizing Single Boxes at the supplier, there was no compelling reason to change the existing strategy. There would be no quality improvements, the lead-times would not decrease, and for the most part, costs would be higher. From an analytical point of view, there seemed to be no reason to deviate from the existing setup.

Figure 3.13: Results of Cost Analysis (Order of Magnitude)

<table>
<thead>
<tr>
<th></th>
<th>Labor</th>
<th>Transportation</th>
<th>Inventory</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>0</td>
<td>- tens of thousands</td>
<td>+ tens of thousands</td>
<td>0</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>- hundreds of thousands</td>
<td>- tens of thousands</td>
<td>+ tens of thousands</td>
<td>0</td>
</tr>
<tr>
<td>Cross dock:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>0</td>
<td>- tens of thousands</td>
<td>0</td>
<td>+ thousands to hundreds of thousands</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>- hundreds of thousands</td>
<td>- tens of thousands</td>
<td>0</td>
<td>+ thousands to hundreds of thousands</td>
</tr>
</tbody>
</table>

However, there were several caveats with this result. First, the existing supply chain had already been optimized for CRS and the existing products. However, other alternatives existed that could have been better for both CRS and the other products. These were not examined closely because it was assumed that those managing operations for the other products would not be willing to change to accommodate the CRS program. Many
opportunities were lost as a result. For example, Sun could ship configurable options to the supplier for integration for Single Box solutions. In this case, the customer would not see a difference in lead-time, and the supplier could build the solution to order without requiring costly reconfiguration.

Secondly, CRS was a small percentage of Sun’s overall business, but was forecasted to grow. Sun upper management wanted to retain solutions-building capability inside Sun’s factory. Inefficient and manual processes in the factory that existed could limit the program’s ability to scale as upper management intended.

Third, indirect costs of CRS’ existing strategy were difficult to quantify because of aggregation effects. For example, CRS had small volume relative to the total volume sold through the mainline business units, so CRS volume did not affect the supply and production plan at the suppliers. However, because of the spiky and uncertain nature of CRS orders, CRS materials managers often discovered that there were not enough units available in the warehouse to pull. As a result, materials needed to be expedited manually, costing time and resources at the supplier, for the individual business units, and for CRS. These costs were not included in the existing strategy.

Fourth, true cost, quality, and lead-time depended on execution. Although low-cost, efficient solutions may have had high ROI, if there were high implementation risks or delays, an organization may not be able to realize their benefits. For organizations and industries that are constantly changing, developing flexible processes that can be improved incrementally or tailored to the environment might be a better strategy.

CRS also may have been focusing on the wrong thing in looking to outsource to reduce costs. CRS was not seeking to be a low-cost provider of standard boxes; it was seeking to provide high-quality, integrated solutions developed specifically for individual customers. CRS was also seeking to grow customization capability and customer relationships for Sun. This required scalability and customer satisfaction, but not
necessarily a low-cost, efficient supply chain. CRS needed to be careful that its metrics and investments made sense for its business, and were not borrowed from the rest of Sun's low-cost, high-volume business.

Some of the cost savings opportunities identified by CRS that could have been realized by moving to Alternative 2 or 3 could also have been realized by improving the existing process. For example, CRS needed to manage materials removed from standard configurations during customization. The existing process was unwieldy and slow. Although switching to Alternative 2 or 3 would have meant that the removal process would not have to be done inside Sun, streamlining that process would have the same net effect. This is further discussed in Chapter 4.

Another gap came in looking for lead-time data. There was not much visibility into how short the lead-times needed to be or even what they actually were. Some customers were asking CRS to support very short lead-times on single box customizations; however, because these lead-times were shorter than the lead-times for the standard configurations, other business units voiced concern over the opportunity for lead-time arbitrage.

This analysis led to the creation of three follow-on projects:

- Develop a process for streamlining the handling of depopped materials
- Evaluate lead-time performance and the possibility of arbitrage among product groups
- Implement a pilot of the IT change to support bills of material for supplier customization
4 Improving the Materials Depopulation Process

4.1 Motivation for the Depopulation Study

One of the main benefits of Alternative 2 of the CRS customization project cited by CRS managers was that it eliminated the materials waste in CRS solutions requiring hardware removal. Many of the solutions involved removing, or depopulating, part of the standard configuration. No process existed for managing this depopulated material, creating complications both in materials management and in pricing.

Numerous people and groups were involved in the management of depopulated materials. However, because of an overall lack of visibility into the upstream and downstream processes, there was no end-to-end view. Different groups involved in the process complained about various aspects unique to their own group, but without knowledge and documentation of the end-to-end process, no process improvements could be implemented that would benefit the entire system.

Under the existing policy, customers desiring to remove part of a standard configuration were given a credit worth half the price of the removed component. Some customers balked at paying for any part of materials not received. CRS customer program managers recognized that the existing depopulation process was cumbersome, but did not know the cost to the program. As a result, they struggled to determine what price to charge customers for this service. They believed that if CRS could quantify and lower the cost of removing hardware, they could pass these savings onto their customers and generate increased revenue from lower prices. Although others believed that CRS customers were generally not price-sensitive, they agreed that knowing the cost and knowing what discounts could be given would be useful.

4.2 Approach

This investigation was broken into two parts: pricing study and process improvement. The pricing study sought to quantify the cost of the existing process such that appropriate
pricing could be instituted. The process improvement portion sought to recommend process changes that would remedy some of the existing issues. The following approach was followed:

1. Conduct the pricing study
   - Calculate the price that recovers material costs
   - Compare the that price with those of other Sun programs to ensure that the pricing is consistent

2. Document the existing depopulation process

3. Investigate and recommend changes that would improve the depopulation process

4. Implement approved changes

4.3 Depopulation Pricing Study

Currently, when CRS customers requested hardware removal from a standard configuration, they were credited for half of the price of the removed component. The goal of the pricing study was to assess the validity of this pricing policy.

First, the existing prices were examined for alignment with other Sun programs. Currently, customers could receive customized systems for limited product lines through Sun’s XATO program or through an Upgrades program. Figure 4.1 summarizes the pricing policies of these programs and the framework used for this analysis.
Figure 4.1: Summary of Customization Options, Costs, and Prices

Example: Customer orders a standard configuration but wishes to replace the existing memory with an increased memory option.

<table>
<thead>
<tr>
<th>Option</th>
<th>Price Policy</th>
<th>Cost to Sun</th>
<th>Price to Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>Standard config price + option price + integration charge - 50% of price of removed component</td>
<td>Medium (factory overhead)</td>
<td>Closer to Upgrades</td>
</tr>
<tr>
<td>XATO</td>
<td>Sum the prices of all the components used</td>
<td>Lowest</td>
<td>Lowest</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Standard config price + option price + service contract (optional) - 10-20% of the option price</td>
<td>Highest (services overhead)</td>
<td>Highest</td>
</tr>
</tbody>
</table>

For XATO, the price of a system built through this process was simply the sum of the prices of the individual components. Presumably there were no labor and overhead costs that exceeded those of standard configurations. Although there were no removal costs, standard configurations sometimes sold as discounted bundles, so the price for building a standard configuration using the XATO process may have been higher than the bundled price for the standard configuration. However, where available, XATO was the least expensive option for Sun for delivery of a customized server to the customer. CRS therefore needed to ensure that CRS customers would not be able to order a customized server through CRS at a price cheaper than the XATO program. To test for alignment, product configurations that could have been built using the XATO process were also priced as CRS solutions. In all cases, CRS solutions were priced higher; therefore, CRS pricing was consistent with the XATO pricing. 16

Customers could also purchase customized systems through an Upgrades program. This enabled Sun customers to upgrade old Sun products with better or later versions. Customers received a discount on the price of the component to which they were

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16 This was not true for solutions that did not have depopulation. For some solutions with only added options, the CRS price (including the integration charge) was lower than the price for the same system under the external assemble-to-order program. Product Line directors indicated that if Sun moved toward increased customization at the server level, all products would be priced according to materials.
upgrading to and returned the old material. If the customer had a service agreement with Sun, a Sun representative would visit the customer and upgrade the material at the customer site. Removed material, if functional, went directly to Sun’s remanufacturing group. Some customers who ordered CRS solutions could have had the same end product by ordering a standard configuration and then upgrading it through the Upgrades program, although they would not have had their upgraded system until a couple months after purchase.

To test the pricing alignment, existing CRS solutions that qualified for the Upgrades program were priced according to the rules of that program. When these Upgrades prices were compared against the CRS prices, the CRS solutions were priced the same or lower. This meant that CRS pricing was aligned; CRS pricing should be lower because the cost of factory removal was lower than field removal, which required a customer visit by a more expensive service representative. Further, the Upgrades program was more of a promotional program that provided incentives for Sun customers to purchase the latest products. It was not intended to be a customization service.

These results illustrated the lower and upper range that CRS could charge and still be aligned with other Sun programs. To determine the lowest price that CRS could charge, an analysis was conducted to calculate how much Sun would have to charge to cover their costs. CRS customers already paid separate integration fees for labor and overhead, so only material costs were included in the analysis. Total material cost was equal to the resale value subtracted from the standard cost of the product. Under the existing process, there was no standard resale value, so the pricing analysis assumed that all depopulated material was transferred directly to Sun’s remanufacturing group at the standard internal transfer price.

Under these assumptions, CRS could afford to offer customers a much higher credit and still recover all material costs. In some cases, if the customer paid for a small fraction of the removed material, Sun could still receive full cost recovery. However, this did not
account for the bundling discount on standard configurations. If the highest margin component were removed from the bundle, the bundling discount would need to be covered by the remaining parts. This might not be profitable (see Figure 4.2 for three example scenarios).

**Figure 4.2: Margin Erosion**

Three examples reflecting profitability of the existing pricing strategy

<table>
<thead>
<tr>
<th>Parts:</th>
<th>Cost</th>
<th>Price</th>
<th>Price</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis</td>
<td>$100</td>
<td>$150</td>
<td>$100</td>
<td>$50</td>
</tr>
<tr>
<td>Memory</td>
<td>$100</td>
<td>$150</td>
<td>$300</td>
<td>$450</td>
</tr>
<tr>
<td>Hard Drive</td>
<td>$100</td>
<td>$150</td>
<td>$100</td>
<td>$50</td>
</tr>
<tr>
<td>Processor</td>
<td>$100</td>
<td>$150</td>
<td>$100</td>
<td>$50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$400</td>
<td>$600</td>
<td>$600</td>
<td>$600</td>
</tr>
<tr>
<td><strong>Standard Config Price:</strong></td>
<td></td>
<td>$500</td>
<td>$500</td>
<td>$500</td>
</tr>
<tr>
<td><strong>Remove Memory Price:</strong></td>
<td></td>
<td>$425</td>
<td>$350</td>
<td>$275</td>
</tr>
<tr>
<td><strong>Remove Memory Cost:</strong></td>
<td></td>
<td>$300</td>
<td>$300</td>
<td>$300</td>
</tr>
<tr>
<td><strong>Margin:</strong></td>
<td>$125</td>
<td>$50</td>
<td>$25</td>
<td></td>
</tr>
</tbody>
</table>

In example 1 above, all parts have the same cost and price, so the margin is the same. A bundling discount of $100 is given. If a customer wishes to remove the Memory, the customer will be credited half the price of the Memory, or $75. This means the total system cost will be $500 - $75 or $425. The material costs of the chassis, hard drive, and processor is $300. Total margin (on materials only) is $125. In example 2, the memory is sold at a high margin while the other components are sold at a loss. In this case, if a customer removes memory, the margin is reduced to $50. In example 3, when the memory is sold at an even higher margin and the other components sold at a greater loss, Sun stands to lose money if a customer wishes to remove memory. (Note that these are just examples and do not resemble true prices or costs.)

For the actual products examined, this was not an issue; the bundling discount was

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17 These are not real prices but are included for illustrative purposes only.
relatively small, and the total price of components to be removed was also relatively small relative to the entire system. Further, most customers were replacing the removed components with higher performance options.

This study showed that the existing pricing was aligned with other Sun programs, and could theoretically be reduced in order to increase revenue. However, other costs need to be considered as well. Although integration charges should have covered the nonmaterial costs of the existing depopulation process, because the costs were quite high, this was not necessarily the case. Further, the actual salvage value of the depopulated material may have been much higher than assumed. The rest of this chapter examines the existing process in detail.

Finally, pricing should be set strategically. If Sun’s product pricing strategy depended on the sale of options, CRS should not provide credits for removing these options. Similarly, if Sun was setting bundle discounts on standard configurations to provide incentives to customers to purchase standard servers, CRS should not have offered these discounts to customers for customized configurations unless Sun wanted to grow its customization business. Finally, delivering customized boxes was viewed as a premium service to increase a customer’s delivered value. To focus on this advantage, customers should be given a total price that included parts of value to the customer rather than a disaggregate price that reflected the manufacturing process. Even if their pricing had been conducted in this way, they might not want to tell their customers that the customers need to pay for removed parts.

4.4 The Existing Depopulation Process

Data was collected from people who dealt with materials management, supply management, manufacturing, and inventory control to document the existing process. The existing process could be broken down into three sections:

(1) **Materials removal**: the actual process of removing the material from the standard configuration

(2) **Inventory Control**: the process of tracking the depopped material while it remains
(3) Materials disposition and usage: the process of moving the material to a location where it could be used

The process for physically removing the materials was relatively straightforward. The operator building the solution physically removed the material and placed it on a shelf in the factory. The operator would then denote the material as being returned to stock in the computer system. This would automatically trigger an ownership transfer of material from CRS to the Commodity supply planner for the component removed.

Once the material was placed on the shelf, it fell under the responsibility of those running manufacturing and inventory control from the Enterprise Systems business unit. Because the material was on a shelf rather than in a locked cage, a physical count of the material on the shelf needed to be made daily. Further, that count needed to be compared with the count in the computer system and ensure a match. Most variances arose from misidentification of the material in the computer system, generally caused by operator error or because the actual part was not in the computer system.

CRS materials managers were responsible for moving the material on the shelf to a usable location. This involved calling the different Commodity supply planners that owned material on the shelf and asking them where to move the material. However, because the removed material lacked its original packaging, the Commodity supply planners were not able to reuse the component immediately in new systems because they did not have all the information they needed to reuse the component. Therefore, the most popular disposition location was the area in the factory where defective material was sent. Here, the component would be tested to ensure that it worked, properly labeled with its exact specification, and then moved to another specified location for usage. Because of the lack of packaging, this material could not be resold as a new option. Most often, the material ultimately went to the Sun Remanufacturing group. Figure 4.3 shows the projected standard cost of depopped material over time. At the current rate, the total 2006
costs would exceed $1 million.

**Figure 4.3: Project Standard Cost of Depopped Material over Time**

![Projected Value of Removals](image)

### 4.5 Key Issues in the Existing Depop Process

All of the groups that participated in the process agreed that the process was suboptimal and could be improved. Key issues were identified after reviewing all the complaints of the individual groups.

1. **Lack of process automation**
   
The existing process was very manual. Operators removing parts from systems had no visual cue reminding them to update the computer system, and needed to enter information into the computer system by hand rather than by scanning. This triggered many later inventory variances that also needed to be resolved by hand. The lack of default disposition locations meant that CRS supply managers needed to call commodity supply planners individually to determine a disposition location, and commodity supply planners needed to assess every time where the material should be moved.

2. **Lack of aggregate metrics**
   
   Inventory metrics were tracked by individual supply planners, who were generally responsible for many products. CRS removed different components from different
standard configurations, so ownership of depopped material was spread across many commodity supply planners. For each of those supply planners, the inventory on the shelf represented a very small fraction of the total inventory that they managed. However, at an aggregate level, the standard cost and the age of the material on the shelf was not tracked and could not be reported directly, even though it was not an insignificant amount and was expected to grow as volume increased in the CRS program (see Figure 4.3 above). Although the actual projected value was not precise, the order of magnitude was probably correct, and the aggregate result was alarming.

(3) Lack of incentives to move the material
As mentioned previously, although there was a large amount of depopped material sitting on shelves, ownership of this material was spread across many commodity supply planners and represented a very small fraction of the total inventory that they managed. Unless there was a shortage, they had very little incentive to expend any time thinking about this material. For the CRS supply managers, calling the commodity supply managers to figure out where this material should be moved was unpleasant and time-consuming. Because this group was generally strapped for time and resources, they also had little incentive to make the calls. The manufacturing and inventory control groups within Enterprise Systems that felt the pain of having the material sit on the shelf had no authority to expedite materials movement.

(4) Restrictions around material use
The depopped material represented brand new standard parts removed from Sun standard configurations. They should therefore have been reusable across any other Sun system that used the same part. However, Sun used multiple suppliers for its components, and not all the models from all the suppliers were qualified across all Sun systems. Although theoretically the same components should have been interchangeable regardless of supplier, the existing engineering qualification rules prevented this from occurring. Further, the lack of packaging prevented these options from being sold as new standalone options.
4.6 Options for Improving the Depop Process

Two high-level approaches could be used for improving the depop process. The first involved making incremental improvements to the existing process. The second involved removing the need to remove components. Although the second approach seemed to be the correct long-term solution, the first approach was also pursued in hopes of making immediate changes that would improve the process.

For the first approach, a default location was established for the removed material. This way, CRS materials managers would not need to call individual commodity supply managers; instead, once material was removed, it could be moved to the default location. Under the existing process, most of the removed material went to a review area to be tested, and then eventually was sent to Sun remanufacturing. Therefore the most obvious default location was to send the material directly to Sun remanufacturing, which could sell these components as used standalone or use these components to build larger systems. The material could potentially also be returned to the external manufacturer of the standard configuration, or to the component supplier.

Sun’s remanufacturing business was profitable, although because their products were sold as used, they had lower prices. From a process ease perspective, although Sun would not have the highest attainable margin on the product by sending the material to remanufacturing, no system changes would be necessary and so a new process could be implemented almost immediately. The overhead cost savings might have offset any lost margin. Unfortunately, material could only be transferred to remanufacturing by scrapping it. Scrapping material required approvals from the director level and scrap reduction was an overall Sun goal. Although commodity supply managers approved of this idea, most CRS program managers were very reluctant to take this approach for brand new material. They preferred to return the material to the system or component supplier if it could not be reused internally.

However, supplier managers of the product groups did not approve of the idea of
returning non-defective components to suppliers. Existing supplier contracts for the original component manufacturer did not include terms for returning non-defective material. The external manufacturers of the systems indicated that they could use the components, but there would be an additional testing fee (to ensure that there were no defects with the components) as well as a restocking fee for usage. The supplier managers philosophically believed that returning non-defective materials to suppliers was wasteful and did not push suppliers to reduce the cost to make it a viable option.

Given these options, the recommended approach for phase 1 was to have a blanket scrap approval in place so that the material could be sent directly to remanufacturing. In this way, both the value of the material being depopped could be tracked via the scrap metric, and the material would be sent to a location where it could actually be used to generate value for Sun. A parallel project should also be initiated whereby the same products would be completely interchangeable. If this were in place, the removed material could be reused in other CRS or internally manufactured systems.

For Phase 2, using the supplier’s assemble-to-order process would have resolved the issue for some of the product lines. However, because this would not be an option for the mid-range servers, and because mid-range servers were the source of a significant portion of the depopped material, other options should be investigated. Options include having empty configurations or implementing assemble-to-order for only a subset of the configurable options that were often removed, such as memory and drives.
5 Measuring Lead-time Variability

The initial analysis assumed that the total time required to ship a solution was equal to the longest materials acquisition time plus 5 days for assembly and test. CRS and the product groups believed that because CRS was pulling material from the local distribution center, CRS customers could receive customized systems faster than they could receive standard configurations. Product Groups were therefore reluctant to facilitate delivery of customized boxes from their suppliers at a short lead-time. Actual materials acquisition time for CRS solutions was not tracked. The goal of this study was to measure and analyze CRS customer lead-time for any lead-time inconsistencies relative to the Product Groups.

5.1 Existing Lead-Time Metrics

Lead-time metrics were tracked under numerous systems across different groups. Within CRS, the Quote Time (the time to quote a price for a CRS solution) and Factory Cycle Time (work order start to work order complete) were measured and reviewed weekly. Total Book-to-Ship time (the time between an order booking and shipment to the end customer) was tracked by another group within Operations. These metrics were tracked manually or through reports generated by the ERP system.

5.2 Lead-time Inconsistency

Product groups measured lead-time as total Book-to-Ship Time, and set goal lead-times for each product. Because of a desire to reduce lead-time proliferation, Sun offered a small number of lead-time buckets. Many products also had different goal lead-times between standard and non-standard configurations; because of the company policy of providing incentives for customers to order standard configurations, the goal lead-times for nonstandard configurations were always longer than those of standard configurations.

Both the Product Groups and CRS wanted to measure the extent to which CRS customers could receive customized solutions in a faster lead-time than Product Groups could deliver standard products. To measure this, the total Book-to-Ship time was
measured for all CRS solutions in the Americas for five quarters (Q103 – Q104), broken out by product group. The number of times that the Book-to-Ship time of a CRS solution was delivered in under the goal lead-time set by the product group (both standard and nonstandard) was counted. The analysis was separated between the Standard and Specialized CRS solutions; because most Specialized solutions had third party parts that could not be pulled from stock, these solutions should have displayed less evidence of shorter lead-times.

The results showed that for Specialized solutions, more than 75% of CRS solutions were delivered in a total lead-time higher than the goal lead-times for both standard and nonstandard configurations. For Standard solutions, more than 75% of the solutions were delivered in a total lead-time higher than the goal lead-times for standard configurations. Although more than half were delivered faster than the goal lead-time for nonstandard configurations, the products driving this result (mid-range servers) did not actually offer nonstandard configurations, so these goal lead-times were irrelevant. Although there were instances of CRS delivering customer orders faster than the product group goal lead-times (25% of the time), this was not done at the widespread level that product groups and CRS engineers seemed to believe.

5.3 Lead-Time Variability and Book-to-Ship Breakdown

CRS had seen a steady decrease in quote time and factory cycle time. The results of the lead-time arbitrage surprised CRS program managers, who did not realize that customers were receiving their solutions much slower than the 5-day factory cycle time. CRS had never tracked total Book-to-Ship time even though this metric directly impacted the CRS customer experience and was the metric used by the Product Groups to measure lead-time performance.

Figures 5.1 shows a histogram of the total Book-to-Ship time across all CRS standard solutions. Figure 5.2 shows the cumulative distribution. Five quarters of CRS orders data (Q103 – Q104) were included. Additional graphs were generated for individual product lines, but the shapes of the distributions of individual products were similar to the
aggregate result.

**Figure 5.1: Histogram of Total Book-to-Ship Times for CRS Standard Solutions**

Histogram of Book to Ship Times

**Figure 5.2: Cumulative Distribution of CRS Standard Book-to-Ship Times**

Cumulative Distribution - Book to Ship Times

The average Book-to-Ship time and the right tail of the histogram were both much higher than expected. The product groups measured their goal lead-times against what they could deliver 90% of the time; that is, they sought to meet their goal lead-times for 90%
of their orders. Using this same metric, the lead-time at the 90th percentile for CRS solutions was outside of what CRS program managers considered acceptable. Factors driving this extended and variable lead-time needed to be examined.

One hypothesis for the long and variable lead-times among the Specialized solutions was a "pilot build effect." The first time a new solution was built, new processes were initiated, which lengthened the amount of time it took to build the solution. This analysis quantified the pilot build effect by plotting the total Book-to-Ship time against how many times the solution had been built (see Figure 5.3). This shows clear exponential decay and a classic experience curve\(^{18}\); extended lead-times exist for the first five builds. However, there was still a large amount of variability even after the first few builds; pilot builds did not drive all of the variability.

**Figure 5.3: Pilot Build Effect**

In order to get a better view of the other factors driving the lead-time, total Book-to-Ship time was disaggregated into its component parts: Materials Acquisition (Book to Work

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Order Start), Factory Cycle Time (Work Order Start to Work Order Complete), and Work Order Complete to Ship. The data systems were not integrated such that one report could be generated for all the lead-times; data therefore needed to be collected manually, and was only available for a subset of the results.

Total Book-to-Ship time was broken into its component parts for the most recent quarter. The breakdown confirmed that most of the lead-time variability was caused by the materials acquisition process, which took almost half of the total Book-to-Ship time, and dramatically exceeded the theoretical one day lead-time. In most cases, factory cycle time was within the goal, and the time between work order complete and the ship time was relatively stable.

The materials acquisition time was also most strongly correlated to the total Book-to-Ship time (see Figure 5.4) with an adjusted R2 was 0.69. Factory cycle time showed some positive correlation with total Book-to-Ship time, but the effect was not as strong. Adjusted R2 was 0.38. Work Order Complete to Ship time showed almost no correlation with total Book-to-Ship time (adjusted R2 = 0.065). Based on these results, materials acquisition was the factor causing most of the variability in total lead-time.

**Figure 5.4: Correlation of Book-to-Ship Components with Total Time**

**Adjusted R2 = 0.69**
To summarize:

- CRS had higher and more variable lead-times than expected
- Longer lead-times existed for the first few builds (pilot builds), showing evidence of learning. This also implies that the systems supporting pilot builds were not allowing CRS to achieve low lead times on the first few passes (probably because of manual process, etc.)
- The materials acquisition process had a much higher contribution to the long lead-times relative to factory cycle time.
5.4 Lead-time Impact from Cross-Docking

The results of this study had implications for the impact of Sun's cross-docking initiative on CRS. The replacement of the distribution center with the cross-dock meant that material could no longer be stored at a one-day lead-time away. Some CRS managers believed that CRS would need to store finished goods inventory at the factory in order to deliver against its existing lead-times. Some advocated engaging in buy-sell agreements directly with the suppliers or the supplier program managers from the product groups, so that the inventory within CRS could be tracked and material would be readily available. However, materials were almost never pulled in just one day, so the lead-time impact of the cross-dock was not necessarily negative.

An additional analysis was done to predict the impact on lead-time from the cross-dock. The key assumption in this analysis was that materials acquisition lead-times would be standardized to the existing goal lead-times set by the product groups after the cross-dock implementation. This existing materials acquisition time was replaced with the goal lead-time of the standard configurations for the product. Factory cycle time and Work Order Complete to Ship times were assumed to be the same. The total resulting Book-to-Ship time was compared against the actual total Book-to-Ship time.

Figure 5.5 shows the resulting cumulative distributions for the existing case and the cross-dock standardization scenario. The standard deviation of the total Book-to-Ship time was decreased by 50%. Although 40% of the orders would have been delivered in a longer total lead-time, the upper 60% would have been delivered more quickly. This shows that CRS should not focus exclusively on reducing factory cycle time; by instituting a policy such that product groups could transfer material to CRS at their existing goal lead-times, variability would be reduced by half and customers would receive their systems faster 60% of the time. Further, CRS should not invest in short-cutting testing or investing in factory improvement processes. From a customer lead-time perspective, standardizing and shortening materials acquisition would have the highest benefit to customers. Although some customers do receive the solutions at a slower lead-
time (because previously their material could be pulled in one day), if short lead-times are important to these customers, other alternatives could be adopted, such as air-shipping systems from suppliers to the factory.

**Figure 5.5: Comparison of Lead-time Cumulative Distributions**

This analysis assumed that all the materials arrived to the factory without defect. However, currently, obtaining material to replace a defective product was an expedited process; replacement material could be pulled from stock into the factory in one day or less. For the cross-dock case, if material is no longer stocked at the distribution center, unless the material is air-shipped, it could take longer than one day to receive replacement material.

A simulation was conducted to illustrate the impact of failures for a generic CRS solution, four mid-range servers integrated in a rack (see Appendix 2 for model details). Three scenarios were considered:

1. **Optimal cross-dock**: All materials, including replacement, arrive within 1 day of the goal lead-time.
(2) Optimal warehouse: Normal materials arrive within 1 day of the goal lead-time, but replacement materials arrive in 1 day.

(3) Existing warehouse: Existing distribution of Book-to-Ship data

Failures are assumed to be independent at the current defect rate, and assembly time is standard factory cycle time. Procurement lead-time is assumed to be normally distributed with a mean and standard distribution consistent with existing performance. Figure 5.6 shows the distribution of procurement time + assembly time for the three scenarios. For the optimal cross-dock, failures drive a second plateau in the distribution; the 95th percentile for lead-time is 30% higher than the same statistics in the optimal warehouse case. However, both scenarios perform better than the existing case with non-standard procurement lead-times.

**Figure 5.6: Lead-Time Distribution including failures for the optimal cross-dock, optimal warehouse, and existing scenarios**

**Lead-Time Distribution for Cross-Dock**

5.5 Recommendations

The lack of standard process by which materials from Product Groups could be pulled into CRS was probably the main driver for variability in materials acquisition. Although there were some shortages and quality recalls that delayed materials, these only affected a
small number of products, and could not explain the large variability across all product groups. Although the Product Groups had goal lead-times for their customers, CRS was not treated as a regular customer, but as a non-standard internal materials transfer. The systems were also not integrated such that CRS could receive the materials in an automated way. Materials managers relied in internal networks to obtain material. Although CRS spent time and resources on improvement projects designed to decrease factory cycle time, very little effort was spent improving the material acquisition process. The costs of the manual and nonstandard processes were invisible.

The results of the pilot build also have implications for the future strategy of CRS. If CRS has a vision for mass customization, it may need to invest in systems that enable it to move down the learning curve faster. That is, the first time a CRS solution is built should not take significantly longer than any subsequent time. Factors driving the extended lead-times in pilot builds should be investigated.

It was difficult to conduct a quantitative study of the aggregate impact from the cross-docking initiative. CRS solutions are each customized, so establishing a set of default solutions and defect rates to use would have been difficult. However, qualitatively, several recommendations could be made:

1. **Track customer facing metrics.**
   CRS focused on factory cycle time and quote time metrics. Although these metrics did impact the customer, total Book-to-Ship time should not have been ignored.

2. **Focus on the 90%, not the mean, when setting goals.**
   The average total customer lead-time was as expected; however, when looking at the upper end of the lead-time cumulative distribution, the lead-times were extremely long. Focusing on the average total lead-time ignored the half of the customers who receiving materials at a much longer lead-time. CRS should focus on the 90th percentile lead-time, or the lead-time under which 90% of their customers can receive their solutions.
(3) **Spend resources where the most significant improvements can be made.**

CRS focused on reducing quote time and factory cycle time. Although most people knew that materials acquisition was a cumbersome process, improving materials acquisition was given a low priority and changes that would have automated the process were delayed. However, materials acquisition made up more than half of the total time and variability of the total customer lead-time, and should have been given a higher priority for improvement.

(4) **Assess the impact of lead-time on customers.**

In most retail environments, inventory and operations policies are set depending on a target lead-time. For CRS, the lead-time was not set in advance, but rather the result of the other activities. Because some of the solutions were very expensive and complex, it was not clear that this was even an issue for customers. Although anecdotal evidence existed of customer complaints and lost sales from extended lead-times, the total impact to the program was difficult to assess. Standardizing and automating lead-times would have reduced cost for CRS and reduced variability in customer experience. However, before making new investments that would reduce customer lead-time with no cost reduction for CRS, customer feedback should be solicited on what would be considered a reasonable lead-time.

(5) **Design the supply chain to account for failures**

Although the cross-dock would theoretically cause no impact to customer lead-time if there were no failures, customers would see a more significant impact to lead-time in case of a failure. The defect rate of the integrated solution was much higher than the defect rate of each component; for more complex solutions with more products, significant delays could result. CRS should encourage product groups to strive for lower defect rates such that the aggregate defect rate for CRS is reduced. CRS should also partner with the Product Groups in designing Six Sigma projects that reduce the defect rate. In the meantime, CRS should consider air-shipping or in-process servicing of
defective materials to reduce the delay caused by failures. Further, if defect rates are expected to be high, CRS should only use standard configurations, as these increase flexibility for in-factory materials exchange.
6 IMPLEMENTATION CHALLENGES AND PILOT RESULTS

CRS needed to learn more about the true benefits and costs of using suppliers’ customization capability. A pilot was proposed for integrating supplier customization with CRS for two low-end volume server products. The lowest impact, most scalable solution for CRS to integrate required changing the bill of materials structure in the ERP system. Other options all involved manual processes and tool changes for CRS, Product Groups, and external manufacturers.

CRS had a flat manufacturing BOM; that is, all components of a CRS solution were located directly under the top level. No hierarchy existed, and only one work order was executed through the factory. Volume servers also had a flat BOM, and used this BOM to communicate information to the external manufacturers. One way to integrate a customized server with a higher-level CRS solution was to change the BOM structure of the CRS solution to allow hierarchy. Specifically, there would be three levels in the BOM: the first level would be the CRS solution; the second level would specify all of the components of the customized solution; and the third level would specify the components of the customized servers that were to go into the solution. In this way, the customized server could be procured with the rest of the order.

However, because the project required an ERP change, it needed to be approved, prioritized against other IT projects, and funded through Sun’s Operations group. This chapter discusses the some of the organizational challenges behind this pilot implementation, things that were done to overcome the challenges, and the results.

6.1 Customization versus Standardization Strategies

Sun’s Volume Server product group mostly followed a standard configuration strategy: they offered small, medium, or large configurations, and relied on downstream channel partners for distribution and customization to end customers. Although some people viewed customization as a risky undertaking that would alienate Sun’s channel partners, others believed that in the future, Sun would need to provide more customized solutions
to stay competitive.

Sun’s volume server group invested in external assemble-to-order (XATO) programs at its external manufacturers that provided custom solutions to large corporate customers for its low-end servers. However, these programs had relatively low volume. The economic downturn placed pressure on product groups to keep costs low, and many questioned the value of these customization programs.

CRS products were built as customized solutions sold directly to end customers (rather than through the channels). Most solutions involved customization of low or mid-range volume servers and/or integration of those servers into larger solutions. This created perceived conflicts. For low-end servers, customers could order customized servers through CRS or through XATO. For mid-range servers, Sun invested in both standardization (through the product group) and customization (through CRS) product strategies for the same products.

The low-end server product groups that had XATO generally viewed CRS as “cannibalizing” their customization business. They did not believe that CRS should customize their servers and believed that CRS should use XATO for customization of servers (and that CRS should only conduct final integration). These groups wanted to partner with CRS to provide short supplier lead-times, and may have seen CRS as a mechanism to drive volume in their customization programs.

The mid-range server groups had a different response. Generally, they believed that offering customization was costly and risky, especially in the current environment, and the existing standard configuration strategy was the most effective. As a result, they did not believe that offering supplier customization was worth pursuing and were not open to initiating their own XATO process to support CRS.

Because of the general disagreement over whether or not Sun should aggressively pursue
a customization strategy, CRS needed to take small steps to improve the existing integration processes with mid-range servers. Although some discussions began that would provide either limited customization or smaller configurations (which would reduce the need for materials depopulation), nothing concrete was implemented. Although this was frustrating for CRS, the mid-range product group was acting consistently with the strategy they had adopted.

As a result, to maintain strategic alignment, the initial plan for the customization pilot only involved low-end servers, even though more volume, opportunities for supplier direct shipment, and depopulated parts stemmed from mid-range servers.

6.2 The IT Change Request Process and Implications

Sun had a matrixed organizational structure; employees belonged to both specific product groups and to functions such as marketing and operations. Product groups operated relatively independently and had separate tools and processes. Although support functions such as marketing and operations were organized by functional group, individuals within those support functions were assigned to specific product groups. Any information sharing across product groups occurred informally.

All Sun product groups shared one ERP system as the system of record for order management. Because of the company-wide dependence on this shared system, changes to the IT system were risky and therefore were subject to a formal change process. Each change request to any shared system required a formal business case and positive ROI. The change request then needed to be presented to a monthly cross-functional council for approval. If approved, the change would be prioritized against other requests. The project would then be scheduled into one of the quarterly releases depending on priority and IT resource availability.

Most people familiar with the process felt that the amount of paperwork required to make changes was cumbersome, and that changes occurred too slowly. Approved projects could be delayed from quarter to quarter because of the lack of IT resources. As a result,
groups often changed business processes or created individual tools to meet their needs rather than follow this process. This behavior was reinforced through Sun's culture. CEO Scott McNealy encouraged employees to “kick butt and have fun;” employees who were proactive and able to effect changes quickly were rewarded. Therefore, there was little incentive to follow the formal process when requesting IT changes.

Unfortunately, this behavior also increased the complexity of IT systems at Sun. Although most product groups struggled with similar issues, the accepted protocol was to create a new process or tool rather than to change a shared tool. This was inefficient; groups often needed to solve the same problems and learn through the same mistakes, and there were no uniform processes across product groups and no forum for information sharing. Each product group also relied on tribal knowledge about any documented process.

Another implication was that the impact of IT changes on different groups was difficult to assess. For example, to implement the cross-docking initiative, representatives from every product group needed to evaluate any proposed system impact individually. Designing a system that accommodated all the needs of all the groups was slow and complex. Even small changes required numerous personal meetings with many other groups.

As a result, the only requests that followed the formal process were those that had no reasonable alternatives. The pilot for this project followed the formal IT change request process. Although it was approved through the IT change request process, because of a lack of IT resources in the company, the change could not be implemented for another two quarters. To increase the priority of the project, CRS partnered with another group that was releasing a new product in the same timeframe. This product group needed to integrate supplier customized servers onto racks; their existing process required creating new part numbers for each customized server. Because the capability CRS needed was
now tied to the release of a new product by another group, priority was escalated and further delays were not anticipated.

6.3 Stakeholder Management

Originally, the only stakeholders identified for this project were CRS and the volume server product groups. However, once the IT change request process began, additional stakeholders emerged with both interest and influence.

The pilot involved changing the Bill of Materials from a completely flat BOM to one that had some hierarchy. This was required because VSP used the BOM to transmit customization requirements to suppliers under the existing XATO process. By introducing hierarchy in the BOM, the existing paradigm for information transfer would not need to change.

A hierarchical BOM for CRS was strongly supported by people within supply planning, finance, and Enterprise manufacturing. Sun products had many shared components that needed to be stocked both internally and at Sun external manufacturers. In order to plan effectively at the component level, supply planners needed to track which components went into which higher level systems. CRS’ existing BOM structure did not provide this information. Finance also had difficulties with the existing CRS BOM structure; at the end of the quarter, they could not reconcile which product group could post the revenue for options purchased through integrated systems. Finally, Enterprise manufacturing had a hierarchical BOM for its processes; every time a CRS customer wanted a system that included a high-end server, this manufacturing group needed to follow a separate exception process to flatten its BOM.

A hierarchical BOM provided information that both supply planning and finance needed for planning and consumption reconciliation, and manufacturing consistency for enterprise servers. These three groups had pushed for BOM hierarchy within CRS numerous times, and their representatives approved the IT change request. Others interpreted the official project approval as admittance that the original decision to have a
flat BOM for CRS was a mistake, and that existing efforts to design tools to accommodate the flat BOM were unnecessary.

However, CRS approved a hierarchical BOM for the pilot only. It did not intend to change the BOM structure of all of its solutions, because the flat BOM significantly reduced complexity in CRS manufacturing processes. Managing the BOM project in a way that did not set unrealistic expectations for other groups or compromise manufacturing process for CRS was difficult. All oral and written communication was made with care; perceived issues and benefits needed to be analyzed to ensure that they were valid for the pilot.

Frequent communication about the project status was made to the stakeholders, and project goals and scope were documented. Finally, another project was initiated to examine and to seek resolution to the challenges that other groups were having with the flat BOM. In this way, the BOM issues of the other groups could be decoupled from the existing pilot.

Half of the overall project was spent defining a solution and presenting a business case for integration between CRS and contract manufacturers. The other half was spent communicating with various groups to increase support and quell fear. For this project, the accuracy of the business case seemed almost irrelevant for implementing the project. Resolving strategic inconsistency and managing the stakeholders to ensure continued support were required to continue the project. Clean execution will be needed for completion.
7 CONCLUSIONS AND FUTURE RESEARCH

This thesis evaluated the CRS customization process. This chapter lists some best practices for any other company seeking to build customization capability and concludes with some suggestions for future research.

7.1 Best Practices for Building Customization Capability

CRS was launched as a grass-roots customization effort in an organization without a clear operations strategy. Although they have been able to grow revenue and deliver systems successfully to customers, they have struggled with scalability and implementing change. The following items would help them and any other organization that is seeking to grow customization.

**Define a clear customization strategy with strong executive support.** CRS was a grass-roots effort. Although CEO Scott McNealy has used CRS as an example of Sun capability and future direction in sales calls, his true commitment to customization is yet to be determined. Because most of Sun follows a build-to-stock, standard configuration strategy with channel partners performing customization, lukewarm support from the CEO results in suboptimal implementation. CRS does not have the necessary support from the product groups to be able to push true changes that will grow the customization business. Customization will never grow to be a source of competitive advantage for Sun unless there is clear direction and support from the CEO.

**Align the customization strategy with the rest of the organization.** CRS began as a somewhat renegade group that built customized solutions for one customer. At the time, using informal processes and nonstandard tools to deliver solutions was appropriate. Now, the program volume has grown significantly, and the impact of these informal and nonstandard processes is impacting other product groups negatively and limiting the programs' ability to scale. Rather than continuing to operate in a silo, CRS should recognize its dependency on other Sun groups and seek to involve other groups.
Design the supply-chain to be appropriate for the customized products. Sun’s volume product group designed its supply chain around efficiency; investments such as demand replenishment and direct shipment were made to increase efficiency and reduce costs in the supply chain, and the primary metric driving supply chain decisions was cost.

According to Marshall Fisher’s supply chain framework, a functional product with stable demand and long product life requires an efficient supply chain, whereas an innovative product with unstable demand and short product life requires a flexible supply chain. Customized CRS solutions are inherently different from high-volume build-to-stock servers. Trying to squeeze all the costs out of the operations of these solutions may limit the true customer value.

Further, the existing supply-chain structures need to be appropriate for the product. For example, setting up a new inventory location using a min-max model for options configuration is inappropriate given the nature of demand for these products for customization. Designing the supply-chain to allow for short transportation lead-times from aggregate stocking locations is suitable for these types of products. A paradigm that fits for Sun volume products probably will not fit for these customized products.

Design products and processes with customization and integration in mind. Sun is more or less organized along vertical product groups. These product groups design products to be optimized for individual performance. However, in a customization environment, customers want these products integrated with other options and systems. If the individual products are not designed with these issues in mind, numerous complications could arise that would make customization of these systems expensive and unreliable. Similarly, testing processes should be designed so that individual products work not only by themselves, but also integrated with other systems. This would reduce the costs from quality issues caused by inappropriate design. If an organization really

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wants to build customization capability, it needs to execute on that vision starting from product design.

**Use appropriate customer-facing metrics.** CRS focused on quote time and manufacturing cycle time. As a result, resources and improvement projects generally went to reducing those metrics. However, end-to-end customer delivery time was not tracked. As a result, focus was not placed on the area with the largest opportunity for improvement (materials acquisition) and the area that would drive real value for the customer. In a build-to-stock environment, reducing manufacturing cycle time keeps utilization and productivity high and reduces overhead costs. In a customization environment, however, the importance of manufacturing cycle time must be considered as a part of the aggregate customer delivery time. Customization programs should leverage their relationships with their customers to determine actual customer needs, and measure and improve customer service.

### 7.2 Future Research

Opportunities for future projects that may lead to operations improvement also exist outside of CRS.

1. **Hockey stick demand**
   Almost all Sun products exhibited hockey-stick demand. This caused end-of-quarter production surges, inventory build-up, overtime costs, and shortages. Sun should examine this phenomenon to ensure that the pattern is not self-induced through sales incentives.

2. **Inventory in the channel**
   Sun invested in many change initiatives that sought to reduce its inventory and the inventory held by suppliers. However, not much visibility was given into the inventory held by the downstream channel partners. For some products, the total days of inventory held downstream was an order of magnitude higher than the total days of inventory held by Sun and its upstream suppliers.
(3) Standard configuration strategy
Sun volume servers follow a standard configuration strategy. This would be an appropriate design if Sun volume servers were functional products. However, Sun’s volume servers were not necessarily functional. The product life was relatively short compared to products in other industries. There were also few advantages in scheduling long manufacturing runs since almost all boxes were assembled by hand. Actual end customer demand was also unpredictable; although Sun and its suppliers may not have had many days of inventory, its downstream channel partners carried a huge amount to buffer against uncertain demand and deliver in short lead-times. Sun’s supply chain may not have been designed appropriately for its products.

7.3 Conclusion
Many computer companies are seeking to improve their supply chains in order to compete more effectively in a mass customization environment. The objective of this thesis was to evaluate the CRS customization program and seek to improve it. First, the question of where customization should begin was considered. Data was gathered and analyzed to compare the cost, quality, and lead-times of three different supply chain configurations. The results indicated that using a supplier’s assemble-to-order process, at least in this case, was only marginally better than the other strategies. Many improvements could also have been implemented quickly to relieve the existing pain points in the process without changing the overall supply chain strategy. When designing a supply chain strategy, it may not be appropriate to consider only cost, lead-time, and quality. Customer satisfaction, flexibility, and alignment with company direction are other factors that need to be considered.
Appendix 1: Standard Inventory Min-Max Model

Model Assumptions:

- Demand is stable and normally distributed

Model Inputs:

- Weekly Demand: Average weekly demand for the configurable option.
- Standard Deviation: Standard deviation of demand
- Lead-time: Lead-time of the configurable option (in weeks)
- Holding Cost Percentage: Cost of holding $1 inventory for 1 year.
- Service Level: 1 – Probability of stocking out
- \( z \): constant associated with service level (from statistical tables)

Model Calculations:

- Demand During Lead-time = Weekly Demand \* Lead-time
- Safety Stock = \( z \) \* Standard Deviation \* Square root of Lead-time
- Order –Up-To-Level = Demand During Lead-time + Safety Stock
- Average Inventory = Safety Stock + Demand During Lead-time / 2
- Holding Cost = Cost of Average Inventory \* Holding Cost Percentage
- Max EOL Cost = Cost of Safety Stock \* (1 – Salvage Factor)
- Total Cost = Holding Cost \* (risk) \* Max EOL Cost, where (risk) is how good the company is at managing their EOL process

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APPENDIX 2: SIMULATION MODEL FOR FAILURE ANALYSIS

Simulation Assumptions:
- Procurement lead-time is normally distributed with mean at the goal lead-time and 90% of the deliveries occurring within one day of the goal
- Solution has four mid-range servers integrated in a rack
- Server failures are independent; failure rate is equal to the existing defect rate
- No system will fail more than once (the probability that a system has a defective server and then one of the replacements is also defective is very small given the existing defect rate)
- For the cross-dock: If there is no failure, assembly time is the standard factory cycle time. If there is at least one failure, assembly time double to account for replacement parts
- For the warehouse: Assembly time is always the standard factory cycle time

Simulation Approach:
- Ran Crystal Ball simulation to generate 10,000 samples for the cross-dock and the warehouse cases
- Plotted cumulative distribution against the existing procurement + assembly time
REFERENCES


