HOW SYMBOL TECHNOLOGIES INCORPORATED BOOTHROYD DEWHURST'S DESIGN FOR ASSEMBLY SOFTWARE INTO THEIR CORPORATE CULTURE

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This paper will describe how Symbol Technologies Incorporated, "The Enterprise Mobility Company", has introduced the use of the Boothroyd Dewhurst Design for Assembly Software into their New Products Development Center, DFA process.

About Symbol Technologies

Symbol Technologies, is the Industry Leader in Information Management. Symbol Technologies Inc. is also a global leader in mobile data management systems and services with innovative customer solutions based on wireless local area networking for voice and data, application specific mobile computing and bar code data capture as well as, RFID business solutions. Symbol's wireless LAN solutions are installed at more than 45,000 customer locations, and more then seven million Symbol scanners and application-specific scanner-integrated mobile computer systems are in use worldwide. Symbol and it's global network of business partners, provide solutions for retailing, transportation and distribution logistics, parcel and postal delivery, healthcare, education, manufacturing and other industries.

Symbol Technologies Inc. (STI) is a producer of electro-optical products manufactured directly by STI and STI certified global Contract Manufacturers. These products differ in size and complexity from small hand held computers and lightweight, hand held scanners to industrial, fixed mounted Radio Frequency Identification readers (RFID) and rugged industrial, finger mounted scanners. In between those markets, STI also produces numerous products that serve the retail and governmental markets.

Introduction to the STI DFM process

STI products must conform to a variety of design specifications. These requirements range from meeting Federal and International regulatory requirements to specific STI product requirements. Our products must be able to perform in an assortment of environmental conditions along with being able to withstand typical day-to day use by our Customers.

The STI New Products Development Center Process Engineers have the responsibility of working with all engineering disciplines in design and development of new products. Our mission is to develop, maintain, support new processes, equipment, and materials that enable products to be built in a repeatable fashion that provide a high quality, low cost solution for repetitive production which meets or exceeds design for manufacturing. To assist in this mission, STI incorporated the use of the Boothroyd Dewhurst DFA software into our current DFM overall strategy. By incorporating the BDI DFA software in our DFM process, we are able to identify cost reduction opportunities early on in the design process where they can have the greatest impact on the cost.

To be successful in our mission, the STI New Products Development Center team receives full support and backing by our NPDC Management. We also receive support from Engineering and Program Management teams. Without this cross-functional high-level backing, the DFM process could not be successful.

The Process

There are three formal design stages in our STI new product introduction design cycle. These formal design stages are: Concept Review, Critical Review and Final Review. In addition to the formal reviews, Process Engineering will meet regularly with Engineering to review and discuss the design progress.

The first formal design meeting is the Concept Design Review. At this time, both the Marketing and the Engineering teams identify the product requirements and design concepts are discussed. Preliminary component functions and features are reviewed at this point in time in the process. Using the initial information available, the BDI Software is used for the first time to generate the Concept DFA analysis.

The next phase is the Critical Design Review. This is typically when the first full Bill of Material (BOM) will be available. At this point in the review process, specific component features will be discussed and evaluated. A detail discussion of the required processes to support the design will be reviewed and evaluated. This is where the BDI DFA software is the most useful in the process. The DFA analysis fosters, discussions of each part whether they are required by design. The cost impact of each part, part count and processes can also be seen and addressed with the entire Engineering team present.

The Final Design Review is the last piece in the process. It is typically held just before the program releases the design for hard tooling. With the high cost and long lead-time required for tooling, this final review in the design process is essentially the last step in the STI DFA process to have any significant impact in to the product's design. Any subsequent changes to the design after tooling release can cause additional costs to the program and significant delays in getting the product to the market.

How STI introduced the BDI DFA Software into our DFM environment

Once the decision was made to incorporate the use of the BDI DFA Software into our DFA a number of decisions had to be addressed. Through lessons learned from numerous programs, we developed a series of questions based on the 4-W's (who, what, when and where) on how to design and develop a successful DFA process integrating the use of BDI software. By answering these questions early on in the development process, we were able to establish a consistent DFA process that is now performed regularly and involves all engineering disciplines.

Who should be involved in the DFA process?

During the three design reviews all Mechanical, Electrical and Process Engineering disciplines are key participants along with their engineering peers. Marketing, Service, Quality and Industrial Design are extended participants in the reviews along with Program Management team members. This allows for a diverse group of disciplines to have input in the final design of the product.

What Products should have a DFA performed on?

The criteria for all new STI products will have DFA performed using the BDI Software. Besides new products, it was established to review and baseline existing released products. In addition we have also started to perform benchmarking of our competitive products.

When should the reviews be held?

Milestones are set with in the program schedule for the three major design reviews. The DFA reviews happen concurrently. This allows for immediate feedback and does not slow down the product design process. As part of concurrent engineering process, we also have informal meetings with Design Engineering as required throughout the product development cycle.

Where should the DFA be held?

The DFA reviews are to be held either during or shortly after the completion of the Engineering Design Reviews. They should be in a formal setting with engineering present. The DFA analysis should be completed with core team members present answering the minimum part criteria question. This fosters key discussions on part count and design requirements.

Getting the STI DFA Process started using the BDI Software

What type of product will be reviewed at the Concept review?
There are three product types to be considered; 1) New Designs, 2) Next Generation Designs, and 3) Benchmarking of major competitor's product.

What information is available for each type?
For new designs a minimal part's list is manually inputted into the Product Structure. For Next Generation designs the original BOM is imported into the product structure and modified. For Benchmarking of our competitor's product the part structure is generated during the initial product teardown.

After completing the BDI DFA analysis what happens?
A detail report is generated highlighting a number of design attributes;

1) Number of components
2) Number of processes
3) Estimated labor time
4) DFA Index
5) Notes: good and bad attributes are identified. Suggested design improvements and tooling and fixture design comments
6) Pictures as required are used to highlight some key features of the design.

The DFA summary report is then circulated to the product team, engineering and management. It is a DFA snap shot of the current design. This is now used to benchmark design improvements as the design progresses during the development cycle. By supplying this breakdown, it allows all disciplines to concentrate on the larger issues identified during the DFA review and not get bogged down in less important design matters. The larger issues usually tend to take care of the smaller ones. The fully exported BDI DFA product worksheet is always available to the entire team to review at their discretion.

On subsequent design reviews, additional tabs are opened up in the original Product BDI Software file. This allows easy, side by side, comparison at all review stages. All of the data is in a single place and can easily be accessed and compared. For competitor benchmarking, these files are placed along side the STI equivalent product file.

The following two Symbol Technologies case studies are programs that have successfully used the BDI software in their DFA review process.   The first case study describes how DFA process was used for a “Next Generation” product type and the second case study describes how BDI reduced costs and a “New” product type.

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Case Study #1: Gemini

Introduction

This study discusses the detailed process used for redesign of a next generation industrial hand held computer product at Symbol Technologies. The case study focuses on the Design For Assembly (DFA) aspect of the project. We will examine the various tools and techniques used to reduce part count, reduce assembly labor, increase throughput, and reduce overall product cost.

Evaluation of First Generation Product

The first step in the product re-design process was to assemble a multi-functional team, led by the Program Manager. The team consisted of representatives from Mechanical Engineering, Electrical Engineering, Manufacturing Engineering, Quality, Marketing, and Service. Other departments contributed to the process but were not part of the core team that met regularly. Since the project charter was to design a next generation product, the team had to first analyze the existing product. This analysis was multi-faceted. The team focused on product features, performance, cost, supply-chain issues, assembly concerns, and design constraints.

To better understand the current product and identify opportunities for improvement, the team performed a part-by-part analysis using the BDI DFA software program. The complete product structure was entered into the software program and a series of BDI questions were answered for every part and assembly. The main focus of this exercise was to determine if each part met the minimum part criteria as defined by the DFA software. This determination was made based on the part’s function and how it fit into the overall assembly. The team studied each item to determine if it would be possible to combine it with another assembly or eliminate it completely. At the end of this exercise, reports were generated from the DFA program, identifying candidates for elimination and listing important notes relating to each part and assembly. This data was then distributed to the team and follow up discussions were held. The current product analysis was saved as a baseline of the existing product DFA score (see table 1).

	Current Gemini
Number of Parts	96
Estimated Labor (sec.)	1038
DFA Index	6.8

Table 1: Baseline of Existing Gemini Product

Another important exercise in the product design process was to gather lessons learned from the predecessor product. Since this product was currently in production, many of the issues related to product quality, first pass yield, supplier concerns, and assembly problems, were well documented. Gemini was one of Symbol's most successful products and as such, the company placed a high level of importance on eliminating production issues. A separate team of engineers from the New Products Development team was continuously working with engineers from the production facility to solve these problems.

The design team tapped into this valuable resource. The lead Mechanical Engineer and Program Manager visited the production facility along with the lead Manufacturing Engineer, so they could see some of the difficulties associated with the current Gemini. This visit was crucial to the success of the re-design program. Seeing the assembly line and the DFA issues firsthand was essential to getting the design team to appreciate the scope and importance of the challenge. The fact that these individuals were not involved with the design of the current Gemini, made it even more critical. With the review of the existing product complete, the team was ready to begin development of the next generation product, armed with the vital information necessary to drastically improve an already successful product.

Product Redesign Process

Design Constraints

The Gemini product is essentially a family of products. It is a rugged hand held computer for the enterprise customer that is offered in a variety of different model types and form factors. There is also an existing suite of accessory products that the new design has to be compatible with. The company has a considerable installed base with key customers and the new design must be compatible with the old in many aspects. In addition to being compatible with the accessories, the new Gemini must be offered in all of the same form factor styles, use the same batteries, and incorporate the same removable keypad design.

Design Goals

Based on all of the analysis performed, the team established many important design goals. In this case study, we will focus mainly on the goals related to product assembly and cost reduction. The current Gemini product has too many model variations, which leads to greater assembly costs. A main goal for this team is to drastically reduce the number of model types and available options, while offering the best value to our customers.

The various models of the original product were developed in series and as such, some of the design choices that were optimal for the first model type, were not the best for models that followed. Therefore, the assembly of the product varied greatly from one model type to another. This made the assembly process and model change over much more difficult, since all models were assembled on the same production line. A design goal was to consider all model variations in parallel and create a common assembly process regardless of model type.

The last and most important goal was to reduce product cost. This would be accomplished primarily through part reduction.

Detailed Design

The design team held a series of brainstorming sessions to review all of the data from the analysis of the current product. All of the internal electronic components were open for discussion and redesign. The parts and subassemblies were categorized from the BDI DFA analysis, as well as main issues raised during the review of the current production. The current product incorporated a two PCB design concept. The main CPU functionality was on one PCB, and product options were populated on a separate PCB. This enabled the low end product to be offered without an option board at a reduced price and only customers that required additional options would be charged for the added circuitry. The team saw an opportunity to make a significant reduction in parts and cost by going with a single board solution. This concept was also in line with the goal of reducing model types. The elimination of the option PCB and the interconnecting flex circuits represented the largest cost reduction for the new product.

The next major influence to the DFA of the new product was the layout of the single PCB. Many of the issues that the factory was experiencing on the current product were related assembly of different model types that required unique assembly sequences, especially in the area of cable routing. The team focused on this issue by laying out the single board for improved wire and cable management. The goal of a single assembly sequence and common cable routing regardless of model type was achieved. More complex models are built right on top of the less complicated ones and the assembly steps do not change from model to model.

The first Design Concept Review and DFA review were held after this initial phase. The entire design team and their management participated in this effort. The Production Engineers and their Management were also involved in the design process and all design reviews. This was important to ensure that all issues were addressed and that we had a buy-in from all areas of the company. The single board approach and PCB layout concept was enhanced and approved during this review phase.

During the next phase, which was the Critical Design Review, the team reviewed again, every mechanical part in the design in accordance with the minimum part criteria as established by the DFA software. Many parts were combined and eliminated during this exercise. One specific example of this is the main chassis shock mount system. Being that the product was design for a rugged environment and had to survive repeated six-foot drops to concrete, the internal electronics were cushioned by a rubber shock absorbing system. The current Gemini used four separate parts to achieve this function. The new design combines these four parts into a single part. There were several additional examples of part count reduction throughout this phase of the project.

At the end of the detail design phase, the Final Design review was held prior to releasing production tooling. At this time, the team had a bill of material (BOM) that was essentially complete. Part of this final review was to input the BOM into the DFA software and compare it against the original design (see table 2, below). The re-design process was a huge success for the team and for Symbol. Part count was reduced from 96 parts to 77 parts, which represents a 20% reduction in parts. Assembly labor was reduced from 1038 seconds to 865 seconds. This is a 17% reduction in assembly labor. The overall product cost was also reduced by 17%.

	Current Gemini	Next Gen Gemini
Number of Parts	96	77
Estimated Labor (sec.)	1038	865
DFA Index	6.8	7.5

Table 2: Comparison of New Design With Current Product

In summary, the next generation Gemini product design team met all of its required objectives. The new product, once released for production, will address all of the issues related to the first Gemini product while greatly reducing assembly labor and product cost. The reduction in model types and common assembly process will streamline the supply chain and minimize product changeover and set-up time. All of these improvements, coupled with increased functionality and the latest hand held computer technology, will ensure this product’s continued success in the future.

Case Study #2: Calypso

Introduction

The Calypso Program is a new product accessory design for Symbol's PD8500 Terminal. This accessory would be incorporated into the PD8500 product line in our manufacturing facility as well as being able to be retrofitted to an existing STI product that is currently in use in the Retail environment. Major design requirement for this product required that all connections be captivated inside the unit so they could not be accessed from the outside without the unit being taken apart. In addition we had to satisfy both current production and field service at the same time. Due to this requirement there were a number of design and process issues that had to be addressed early on in the Program.

Design Goals

The Calypso product supported three distinctive functions. STI Customers needed the ability to order any combination of these three unique functions. Our challenge was being able to respond to seven different configurations with minimum impact to production and Field Service. Because it is considered an accessory and not the top model product, the cost would drive the success of the Calypso program. The next prevailing concern was Field Service support. The team needed to consider a minimum number of parts that must be stocked and available when a customer wanted to upgrade with any of the latest Calypso accessory configurations. Also included was a requirement to have the fewest possible process operations. This would reduce the amount of labor and service equipment required to support our major service facilities.

Detail Design

A cross-functional team was assembled, and performed a detail BDI DFA analysis on the concept Calypso design. After reviewing the BDI data (ref Table 3), the design showed a large number of process driven operations that required further evaluation. These processes were discussed in detail to understand what was driving them within the design and could they be eliminated or combined with other components.

BDI DFA REIVEW STATUS	Concept Review
Number of Component Parts	53
Number of Process Steps	34
Estimated Labor (sec.)	715
DFA Index	3.3

Table 3: Concept Review Data

The Concept Design called for four individual Printed Circuit Boards. Three of the PCB's each had a unique flex circuit interconnecting them to the Main I/O PCB. Each of these flex circuits had different pin configurations and specific length requirements. As part of this design, the flex circuit assemblies each had to be manually formed into unique configurations using supplementary fixtures. Each flex added additional non-reoccurring costs for fixture design and fabrication, as well as the additional Labor per unit to assemble. After the flexes were formed, their routing within the unit required additional process steps.

Another constraint was the accessibility of the PCB's inside the unit. The unit was required to be closed up to restrict tampering of the flexes. An additional security cover and mounting screws were needed to meet this requirement. These additional parts added to both the part count and process steps.

The team focused on trying to eliminate the unique flex designs. They also tried to eliminate and standardize the flexes themselves. One solution identified was to reduce the PCB interfaces resulting in the reduction of the overall number of flexes. This was accomplished by combining two of the PCBs.

The next step was reviewing the internal routing of the flexes. The team's goal was to simplify the routing of each flex and to remove or reduce the number of bends required to form each configuration. With these changes incorporated the team performed the next phase of the DFA process, Critical Review.

At the Critical Design Review the team obtained a dramatic reduction in process steps. This improvement was attributed to the elimination in the number of PCB interconnects as well as complex forming of the flex assemblies (ref Table 4).

BDI DFA REIVEW STATUS	Concept Review	Critical Review	Percent Change
Number of Component Parts	53	51	1%
Number of Process Steps	34	4	88%
Estimated Labor (sec.)	715	503	30%
DFA Index	3.3	4.7	42%

Table 4: Critical Review Data

With new flex circuit configurations and elimination of a PCB, the team was able to relocate the remaining PCBs allowing for easier access during assembly. Because of the new PCB locations, the team gained an opportunity to remove the requirement for a security cover and it's mounting Hardware. These changes were incorporated prior to the final design review. The Final Review resulted in a significant reduction in parts, a tremendous reduction in the process steps and a huge jump in the DFA index resulting in a very successful DFA product (ref Table 5).

BDI DFA REIVEW STATUS	Concept	Critical	Final	Percent Change

	Review	Review	Review	Critical to Final
Number of Component Parts	53	51	43	16%
Number of Process Steps	34	4	3	25%
Estimated Labor (sec.)	715	503	459	9%
DFA Index	3.3	4.7	8.3	76%

Table 5: Final Review Data

In Summary, using the BDI DFA Software provided the Calypso team with the ability to recognize potential manufacturing problems early in the design process. This allowed time to work on making the necessary changes and improvements to achieve a solid, cost efficient and easily producible design (ref Table 6).

BDI DFA REIVEW STATUS SUMMARY	Concept Review	Final Review	Delta	Percent Change Concept to Final
Reduced Number of Component Parts	53	43	10	19%
Reduced Number of Process Steps	34	3	31	91%
Reduced Estimated Labor (sec.)	715	459	256	36%
DFA Index Improvement	3.3	8.3	5.0	150%

Table 6: Final Summary

Conclusion:
Symbol Technologies has successfully incorporated the use of the BDI Software into their corporate DFA strategy. The results have proven valuable in many different areas. Using the BDI Software STI has seen marked improvements in the following areas:

Simpler and more reliable products.
Less costly products.
Reduced time to market.
Reduction in the number of parts in assemblies.
Increase in the reuse of exiting parts and subassemblies.
Simplified product repair and serviceability.
Valuable tool for benchmarking competitor products.
Reduction in part count.
Reduction in assembly time and labor cost.
Reduction in total product cost.
Improved product quality/performance
Reduction in number of tools and fixtures required.