Using DFA Analysis to Integrate Outside Designs Into the Motorola EMB New Product Development Process

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Introduction

In today's rapidly changing global economy in which we live and work, an increasing number of companies are outsourcing their design and manufacturing activities. As our business continues to grow and new products are added, some of these products are designed and built in-house, while others are developed using external resources. These partnerships result from and are driven toward the bottom line, cost.

With outside companies performing more and more product design and manufacturing tasks, a company's success is ultimately tied to the success of these designs. While these outside firms may have primary responsibility for the overall design, supply chain, assembly and delivery of these products, it is incumbent upon the "parent" company to ensure that these designs meet or exceed all performance requirements, cost targets, manufacturability and serviceability needs and quality goals.

This is one reason why it is important to apply Design for Assembly (DFA) principles, and what makes the Boothroyd Dewhurst Design for Assembly software a valuable tool to help drive the success of these projects.

External Resources for Design and Manufacture

There are several partner relationships available for a company to utilize. Some of the more common are:

1. ODS, Outside Design Service: A firm hired to provide design services, primarily mechanical design and PCB layout, sometimes industrial design.
2. ODM, Original Design Manufacturer: A company that designs and manufactures a product for another company, and can brand the product in that company's name.
3. JDM, Joint Design Manufacturer: A collaborative design effort with manufacturing done at the partner, often offshore to benefit from lower production costs.
4. EMS, Electronic Manufacture Supplier: Primarily involved with design and manufacture of circuit boards.

5. CM, Contract Manufacturer: Firms that build products to someone else's design, often assembly houses with no design capability of their own.

These business relationships drive different types of behavior. Increasingly, the distinctions between these types of companies have blurred. For example, some companies previously known only as EMS houses have expanded their capabilities and value proposition as competition grows, into final assembly as well. This would be similar to a subset of the JDM model.

This paper will focus on how to work with outside design firms to ensure they meet our requirements, control "part creep" and drive cost reductions, and how this is enhanced using Boothroyd Dewhurst Design For Assembly software.

Why These ODM/JDM Relationships Exist

The first step is to understand why a company would contract out intellectual property to another company. In most cases a product design is outsourced for several reasons; manpower, schedule, cost, marketability or often a combination of the above.

To stay ahead of the competition, a company may want to bring a product to market quickly yet may not have the in-house resources to support the rapid design and development of that product. The parent company may not be able to support quick turnaround schedules. Outsourcing design work can provide additional resources for a quick and easy solution to meet accelerated schedules. Outside design companies may have lower costs associated with design and/or fabrication and assembly. Also, they may have attractive purchasing relationships with local component suppliers, which can make them even more competitive. Additionally, to break into a specific market, it might be strategically beneficial to generate a design out-of-house, in that market theater.

Why would a contract design firm want to design products for another company? Quite simply, profit. If a business does not make a profit, sooner or later that business will no longer exist. If they have design resources available they become more versatile and marketable.

Depending on the needs of the parent company and the capabilities of the ODM/JDM, the contract between these firms could include more than just the use of design resources. While each program and contract is unique, these resources could include additional partnerships in: Fabrication and Assembly, Testing, Repair/Service support, Warehousing and Logistics, etc.

How is the product development process different within an ODM/JDM partnership?

In theory, the Product Development process using an outside firm is no different from the in-house process. At Motorola EMB, the typical new product development cycle generally follows a flow such as:

- Marketing Concept / Product Statement of Work
- Concept Design Review (In-House)
    - First entry into DFA SW
- Supplier Assessment (Site Visit / Vendor Survey)
- RFQ
- Supplier Selection (Make vs. Buy decision)
- Specification Finalized
- Design Development at ODS/ODM/JDM
- Critical Design Review
    - DFA analysis of ODM/JDM design
- Design Refinement
    - Additional DFA activities (including quality, test and service inputs)
    - Multiple iterations may be appropriate (feedback loop)
    - Deliverables refined using BDI DFA
- Prior to Release and Manufacture
    - Final DFA assessment

In short, as with in-house designs, we plug the ODM design into the BDI DFA software; evaluate and critique the designs at the concept, critical and final stages; ask questions, push for changes and report results. We iterate this process until the product is ready for release.

In actual practice, there can be difficulties incumbent with working through and communicating with another organization, another bureaucracy. Outsourcing, by definition, leads to loss of control. Depending on the partner, the design interaction could be [mostly] hands-off, or a high-touch relationship with lots of input, review and other involvement. Understanding who the players are, and coordinating design activities, is crucial. There could also be language and cultural differences to overcome.

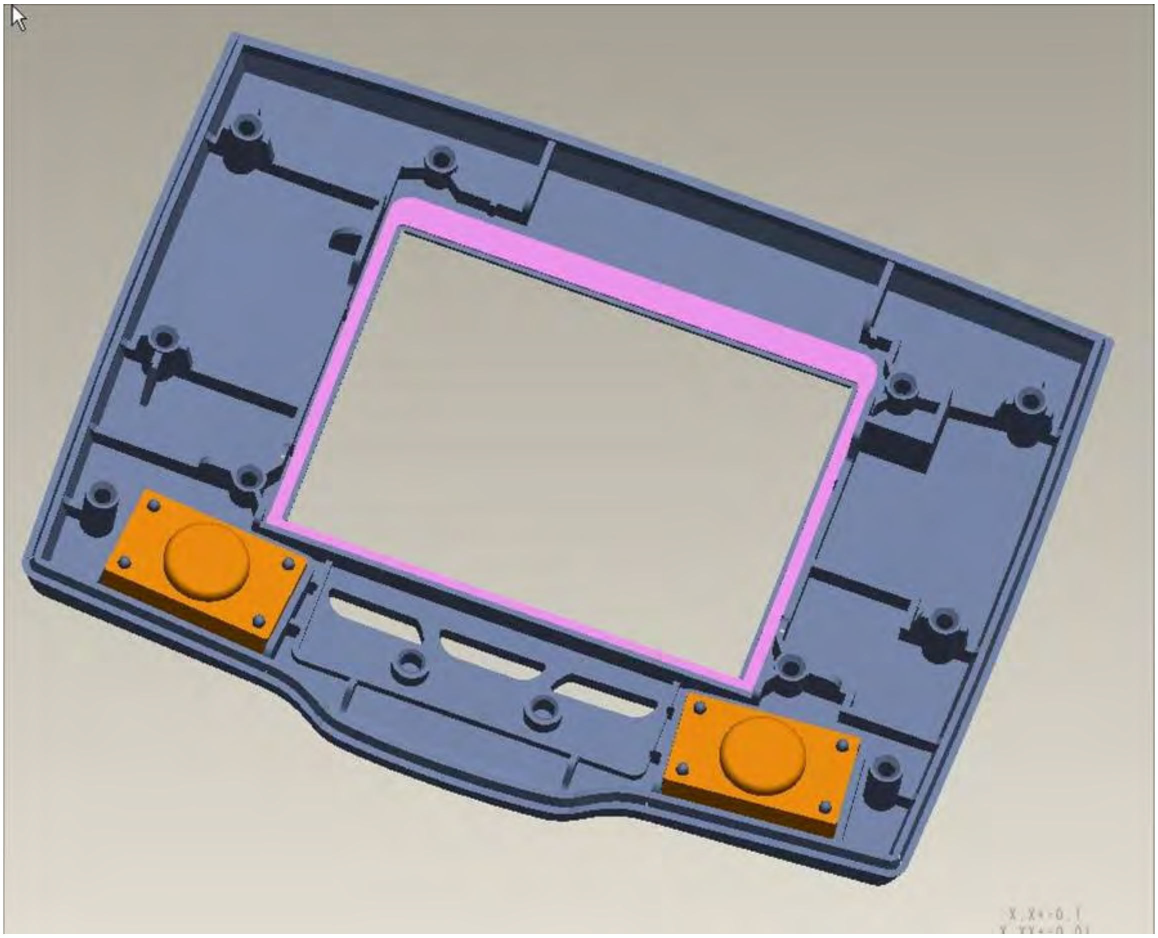
There are typically joint development teams, both internal and at the ODM/JDM, whose involvement will vary depending on the outside firm, the business relationship and the product. Strong program management is required at both ends, as these teams need to be in regular contact. Ongoing reviews of ODM/JDM designs are needed, including definition of assembly and test fixtures, yet it is frequently difficult to exchange detailed information via conference calls or net meetings (the impact of time zone differences should not be overlooked). Formal, face to face design review meetings should be planned for in the schedule, and budgeted accordingly. Informal design discussions should be frequent, where DFA recommendations are explained and incorporated.

Further complicating the development cycle, several different outside firms might have different parts of a job – Mechanical and Industrial design, PCB design/fab, Final Assembly and Testing, Service, etc. Each discipline has different ways of looking at the same issues.

We asthe parent company, ultimately own the design and have responsibility for a successful, high quality product. We must be careful with what we agree to, and must push back when needed to ensure a successful program and product. BDI DFA software is a fact-based decision-making tool to help ensure this success. The following case studies highlight a few examples of how this is done.

CASE STUDY 1: GASKET REVIEW

For sealing and shock protection, a compressive foam gasket is needed between a plastic Housing and a Touch Panel in a small data Terminal. The original design called for a one-piece “picture frame” gasket. The part is flexible foam, die-cut and adhesive-backed. There is asymmetry in the width of one edge, so there is only one correct orientation.



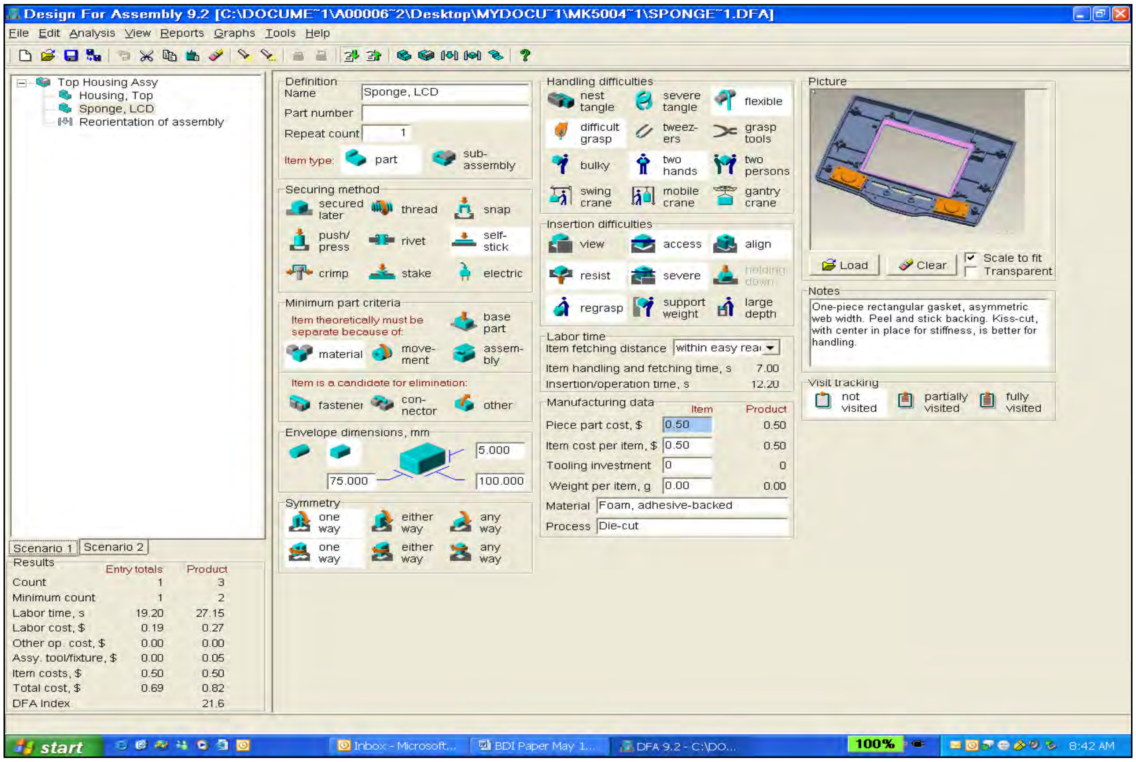
Experience has proven that these types of adhesive-backed gaskets can be difficult to position accurately on all four sides and corners, due to elasticity of the part, strong adhesion, and stretching when removing the adhesive backing. For similar applications on other programs, we have employed assembly fixtures with mounting plates, vacuum retention and guide pins.

Sealing requirements for this product are not stringent, so our suggestion was to replace this single part with four separate pieces, the seams at the corners being of little importance in this instance. Normally, we would lobby for fewer components, not more, but the ease of assembly weighs heavily in this case. We suggested using two parts, a side piece and a top piece, with a Repeat Count of two (2) each. All components would have the same width.

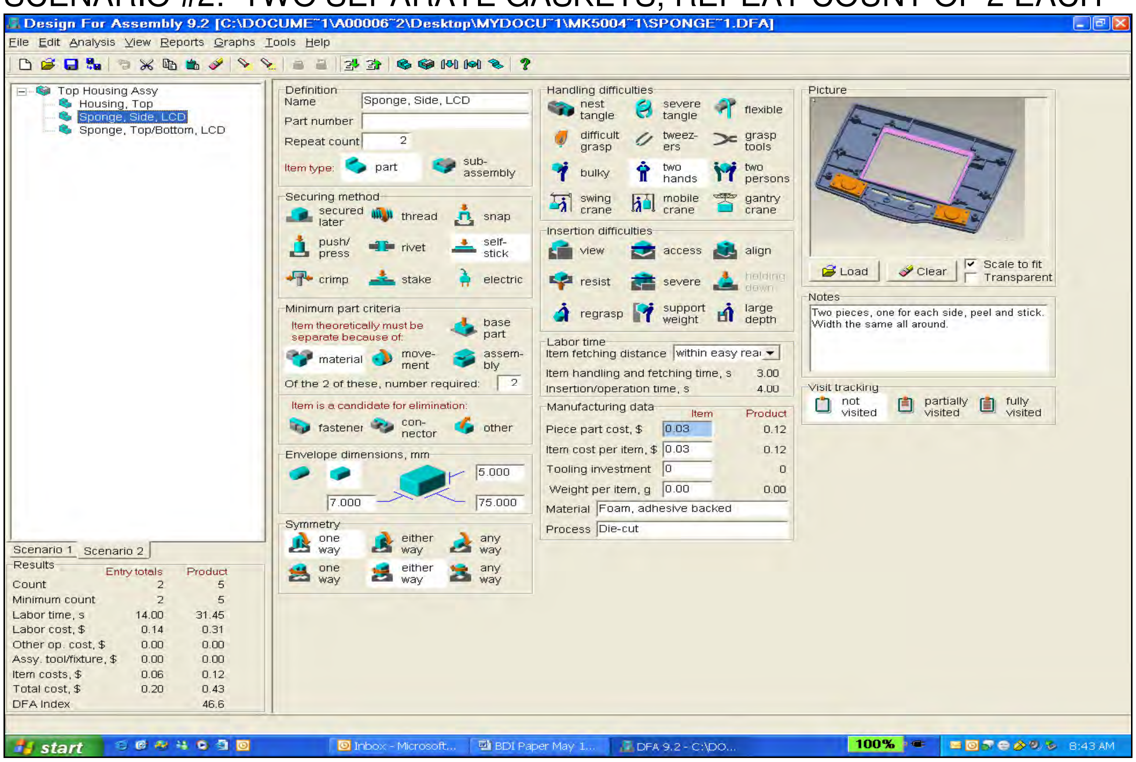
There are several advantages to this. The small straight pieces will be easier to place accurately, with no fixture needed; each piece has a two-way symmetry (either way); parts bins on the work station can be smaller; little or no NRE tooling cost for the supplier; less scrap or dunnage is generated at manufacturing, reducing total material cost and less waste at assembly.

Using the BDI DFA software, we evaluated these two scenarios, the one-piece Gasket versus the four-piece Gasket. Both possibilities were entered into the software, with fixtures, handling difficulty and part cost consideration.

SCENARIO #1: SINGLE-PIECE DIE-CUT GASKET



SCENARIO #2: TWO SEPARATE GASKETS, REPEAT COUNT OF 2 EACH



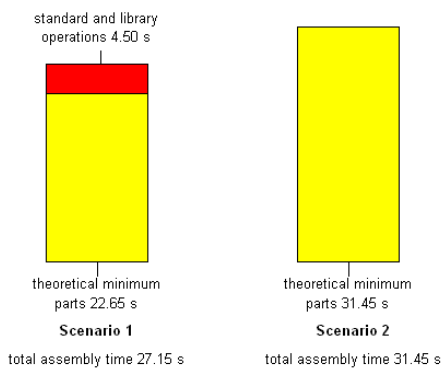
Executive Summary Comparison - DFA

MOTOROLA

Tuesday, May 20, 2008 8:37 AM
Top Housing Assy

Per Product data		Scenario 1	Scenario 2
Entries (including repeats)	Component parts	2	5
	Subassemblies partially or fully analyzed	0	0
	Subassemblies not to be analyzed (excluded)	0	0
	Standard and library operations	1	0
	Total Entries	3	5
Labor Time, s	Component parts	22.65	31.45
	Subassemblies partially or fully analyzed	0.00	0.00
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	4.50	0.00
	Total Assembly Time	**27.15**	**31.45**
Labor Cost, $	Component parts	0.22	0.31
	Subassemblies partially or fully analyzed	0.00	0.00
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	0.04	0.00
	Total Assembly Cost	**0.27**	**0.31**

The chart shows a breakdown of time per product



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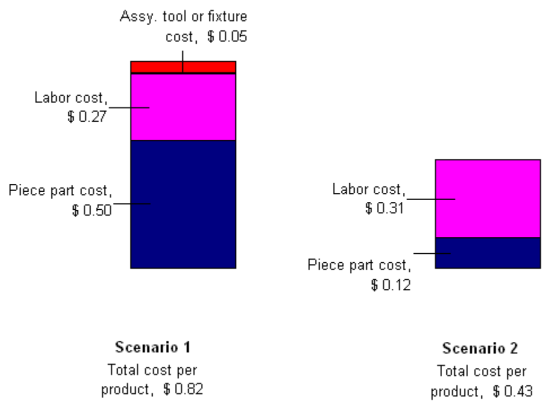
Executive Summary Comparison - DFMA

Tuesday, May 20, 2008 8:38 AM
Top Housing Assy

	Scenario 1	Scenario 2
Product life volume	10,000	10,000
Number of entries (including repeats)	3	5
Number of different entries	3	3
Theoretical minimum number of items	2	5
DFA Index	21.6	46.6
Total weight, g	* 0.00	* 0.00
Total assembly labor time, s	27.15	31.45
Total cost for manufactured items (including tooling), $	** 0.50	** 0.12
Total assembly labor cost, $	0.27	0.31
Other operation cost per product, $	0.00	0.00
Total manufacturing piece part cost, $	0.50	0.12
Total cost per product without tooling, $	0.77	0.43
Assembly tool or fixture cost per product, $	0.05	0.00
Manufacturing tooling cost per product, $	0.00	0.00
Total cost per product, $	0.82	0.43

**Note: Item weight not given for some items. Total weight may be incomplete.*
***Note: Manufacturing piece part costs not given for some items. Total cost may be incomplete.*

The chart shows a breakdown of cost per product



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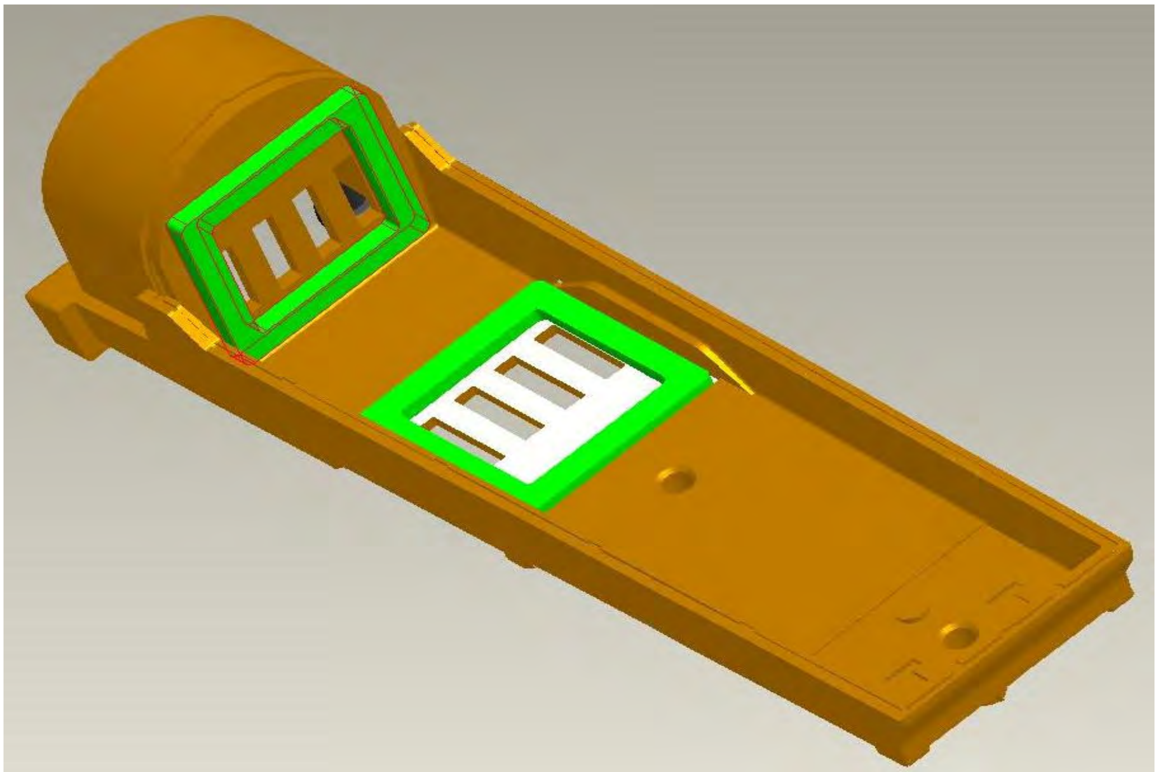
These scenarios were analyzed and compared in the Executive Summary Report for both DFA and DFMA.

SCENARIO	PART NUMBERS	REPEAT COUNT	LABOR (SEC.)	DFA INDEX
1	1	1	27.15	21.6
2	2	2	31.45	46.6

When the DFA Summary is reviewed, scenario #2 initially looks less desirable, as expected, with more parts with more assembly time (although the difficulty of installing the one-piece gasket in scenario #1 should not be underestimated). However, looking at the DFMA Summary and considering piece part cost, scenario #2 has a clear advantage from an overall cost perspective. The DFA Index more than doubled, and using the four-piece gasket will save nearly 48% of total cost, material and labor combined.

CASE STUDY 2: PAD REVIEW

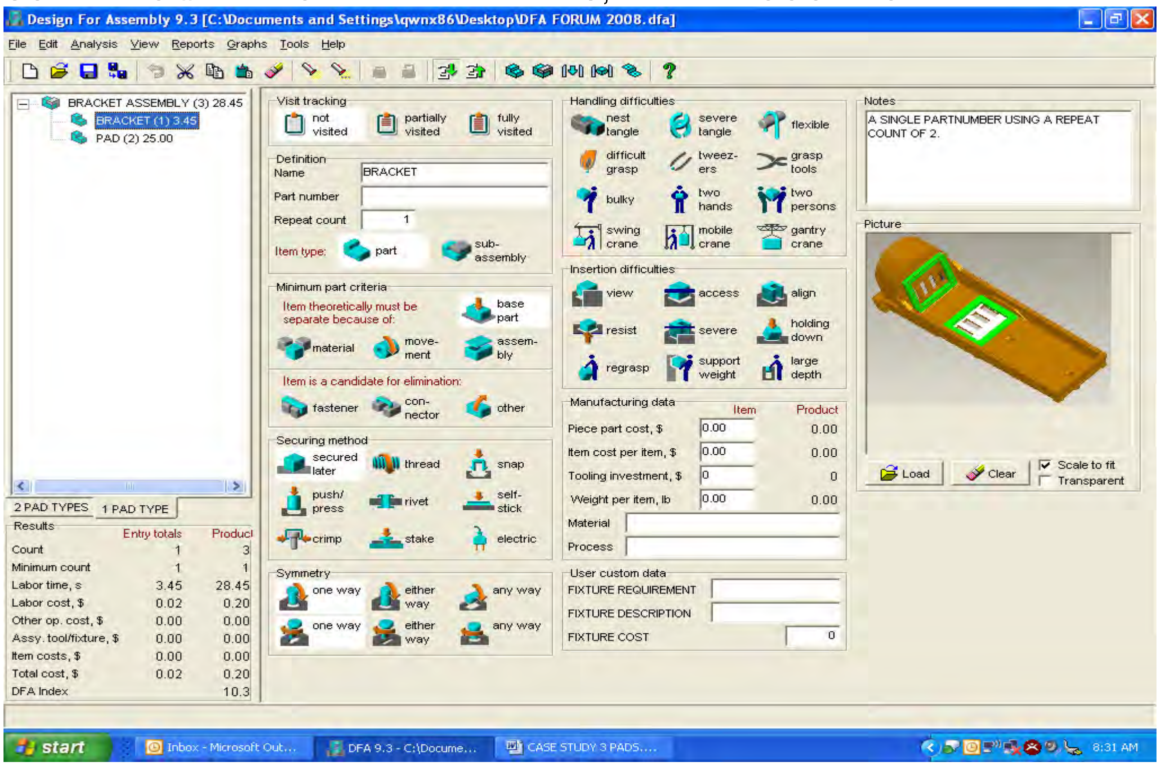
The proposed design challenge by the outside design house was to use two different Pad configurations in this simple Bracket Assembly. After reviewing the design proposal, the New Product Introduction, Process Engineering Group responded with a suggestion to use the same Pad configuration with a Repeat Count of two (2).



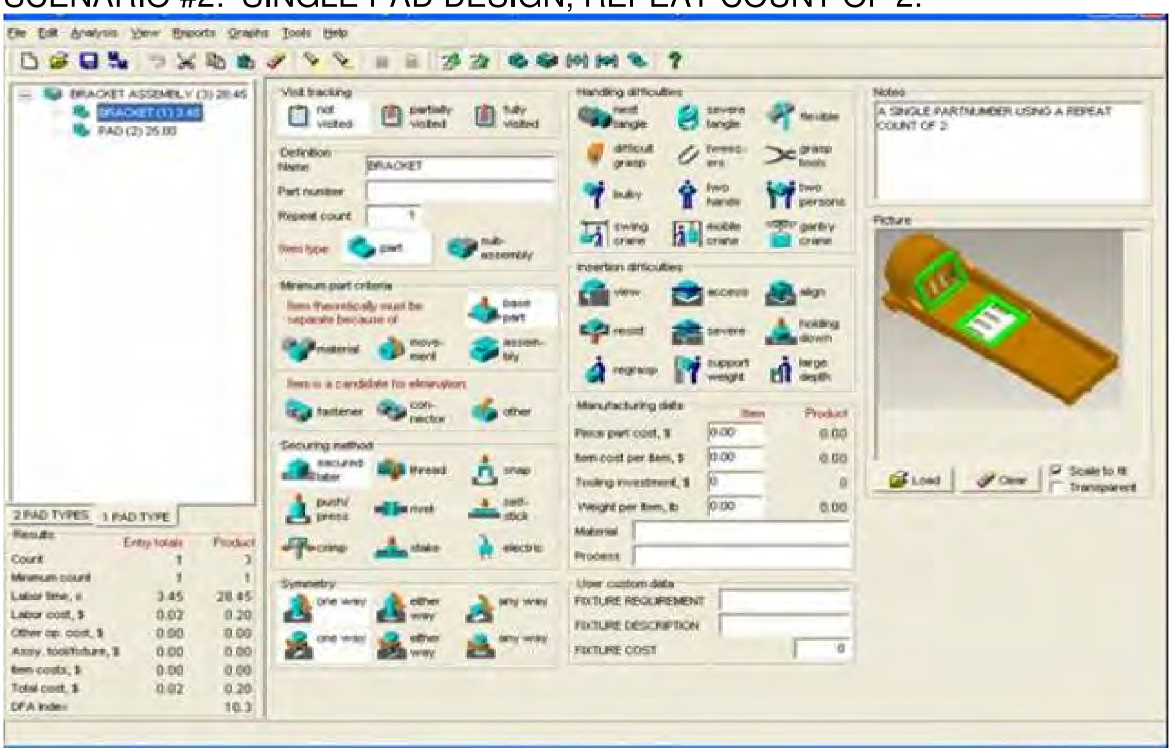
To estimate the merit of this potentially simple design change, an evaluation of the two design proposals was performed using the Boothroyd Dewhurst DFA software. The two Pads were very similar in design and their application attributes. Both Pads were of a peel and stick variety and both were asymmetrical in construction. In the original design, the difference in height between the two Pads was approximately 2mm.

Using the BDI DFA Software, we performed a typical "What if" scenario. Our first goal was to run the software with the two different Pad configurations and a Repeat Count of one (1) for each design configuration. After that we next ran the analysis in the, "What if the two different Pads were the same Pad?" mode, with a single Pad configuration and a Repeat Count of two (2).

SCENARIO #1: TWO DIFFERENT PADS, REPEAT COUNT OF 1:



SCENARIO #2: SINGLE PAD DESIGN, REPEAT COUNT OF 2:



After performing a run-through of the DFA software for each of the scenarios, we then made use of the Executive Summary Report to compare both of our options. The Executive Summary showed us that using two different Pad configurations with a Repeat Count of one (1) or a single Pad configuration with a Repeat Count of two (2) did not influence the cost of the Labor content.

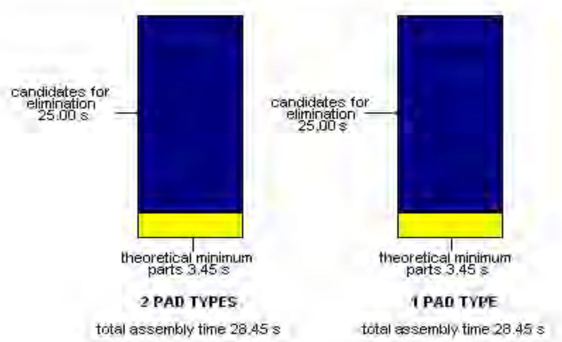
Executive Summary Comparison - DFA

MOTOROLA

Wednesday, May 14, 2008 3:04 PM
BRACKET ASSEMBLY

Per Product data		2 PAD TYPES	1 PAD TYPE
Entries (including repeats)	Component parts	3	3
	Subassemblies partially or fully analyzed	0	0
	Subassemblies not to be analyzed (excluded)	0	0
	Standard and library operations	0	0
	Total Entries	**3**	**3**
Labor Time, s	Component parts	28.45	28.45
	Subassemblies partially or fully analyzed	0.00	0.00
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	0.00	0.00
	Total Assembly Time	**28.45**	**28.45**
Labor Cost, $	Component parts	0.20	0.20
	Subassemblies partially or fully analyzed	0.00	0.00
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	0.00	0.00
	Total Assembly Cost	**0.20**	**0.20**

The chart shows a breakdown of time per product



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Both of the options presented had identical outputs. They both had the same Labor estimate as well as identical DFA Indexes.

SCENARIO	PART NUMBERS	REPEAT COUNT	LABOR (SEC.)	DFA INDEX
#1	2	1	28	10.3
#2	1	2	28	10.3

At this time, the ODM did not see any “value” in redesigning the two Pads into a single Pad design. Discussions were held explaining that not all design issues result in only direct labor savings. There are additional savings that can be achieved by reducing the Part Number count.

Up-front, Non-Recurring Engineering (NRE) efforts can be very substantial and should always be considered in the design effort. Most of these additional costs can be very ambiguous when trying to determine an actual dollar value. NRE estimates costs can vary from company to company and in some cases from one manufacturing plant to another plant within the same company.

Some of the NRE costs associated directly with a simple part design are straightforward to see and somewhat easy to track. These include:

- Design time
- Cost of Tooling
- Prove-out of Tool (samples)

However, there are additional NRE costs that are extremely difficult to quantify and are mostly considered an “overhead function” and their costs get buried in the big picture. These can include but are not limited to:

- Maintaining Quality material (First-piece articles)
- Creating new part numbers
- Maintaining the new part number in the MRP system for the life of the program
- Cost of purchasing the new part each time it is needed
- Cost of warehousing a new part
- Cost of packaging
- Cost of adding a new part to the manufacturing line
    - Cost of pulling the part
    - Cost of adding it to the WIP
    - Additional space at the work station
    - Cost of Quality (Possible error by operator)
    - Additional cost for Service

At the end of these discussions with the ODM, all parties agreed that it is in the best interest to design a single part with a Repeat Count of two (2).

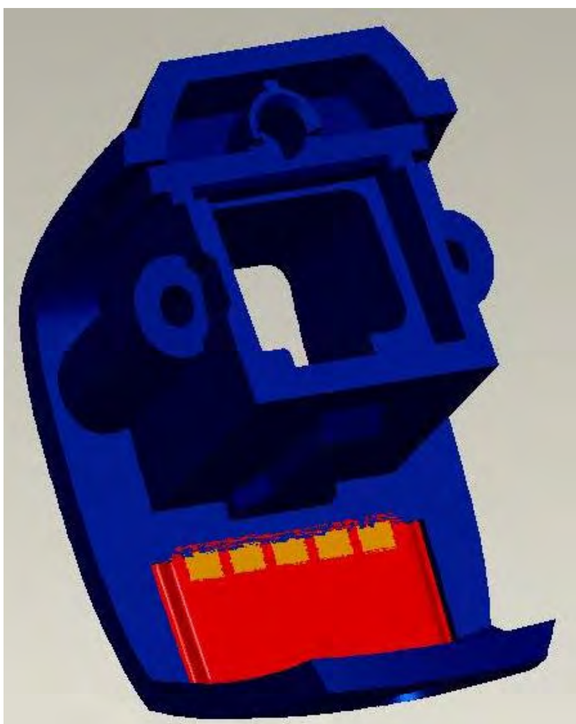
If the design team had been in-House, they would have understood these concerns and designed the two Pads accordingly. To have a successful ODM design, it is imperative that they understand all of your companies' needs and concerns.

CASE STUDY 3: CONTACT ASSEMBLY REVIEW

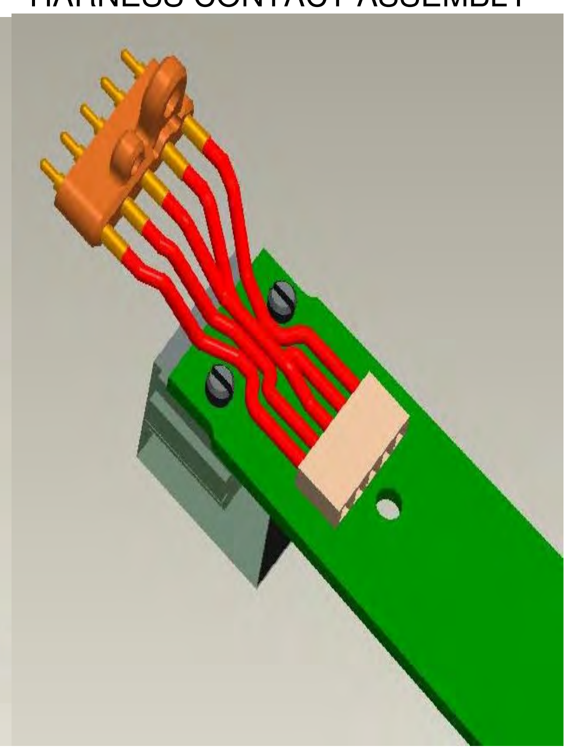
The proposed design from the outside design firm for this Harness Contact Assembly was a Harness with a Contact Block Assembly that would interface with an additional Base Contact Assembly. This would then allow signals to be conducted from the Base Contact Assembly to the Main PCB of the unit.

The original Harness Contact Assembly design proposal was to be plugged into a PCB and then placed into a plastic Housing. When installing this into the plastic Housing, the Harness connection would then become a “blind” assembly for the operator. If the connection was to become disconnected, the operator would not be able to detect it at any other point during the assembly process. This would then cause a failure of the unit and would drive a costly rework to be performed. Also, to hold the Contact Block Adapter in position after assembly, a Screw would be used to secure it to the bottom of the plastic Housing. The Base Contact Assembly would then interface with the Contact Block and the signal would then be able to be transmitted.

BASE CONTACT BLOCK

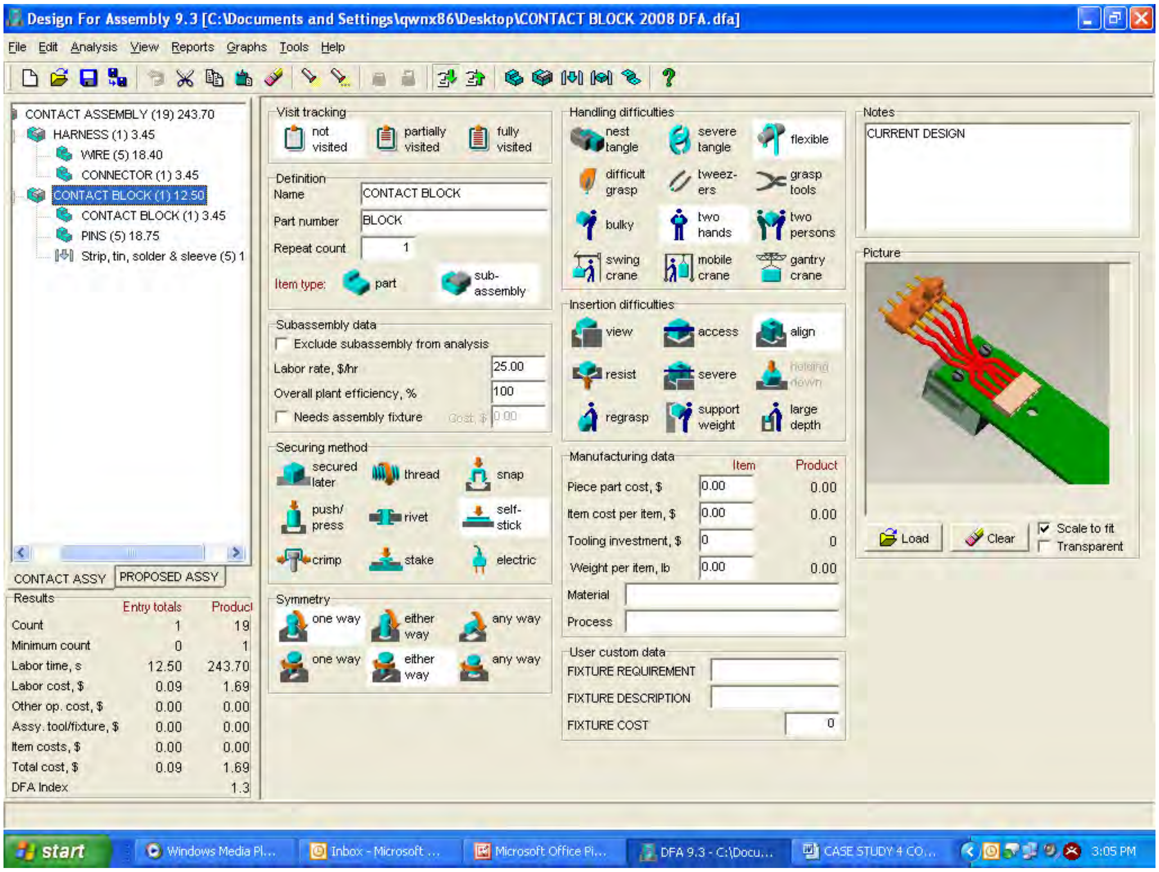


HARNESS CONTACT ASSEMBLY



Our first step was to perform a BDI DFA analysis on the current proposal. This would allow us to establish a baseline for any projected changes in the design and allow us to make an objective decision. Since the concern was focused mainly on the Harness Contact Assembly, we started there with our review.

We broke out the Harness Contact Assembly into two main features. First there is the actual Harness itself (wire and connector) and following that there was the Contact Block and its' components (Block, Pins, Sleeving). Also, because the Contact Block had to be soldered to the Harness we included an Operation to solder and shrink the Sleeving at each Pin.



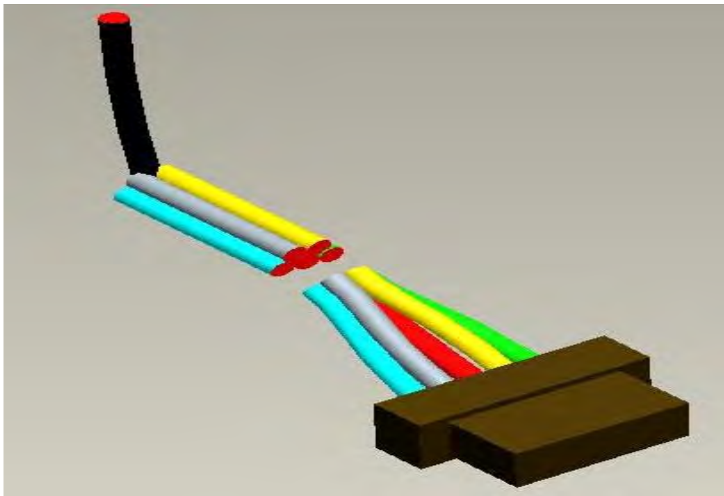
After reviewing the original design we proposed some modifications that would help eliminate parts and reduce the chance of errors during the assembly process.

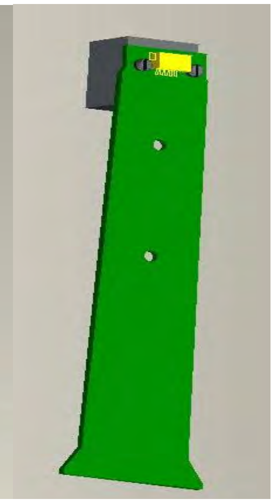
The suggested changes were to eliminate the Harness Contact Block Assembly totally and to reposition the PCB Connector closer to the bottom edge of the PCB so it is accessible from the base of the plastics. This allows the Harness to be inserted into the plastics from the bottom, eliminating the possibility of   the connection becoming disconnected.

Also, we proposed soldering the Harness directly onto the Base Contact Block, eliminating the need for the entire Contact Block Assembly.

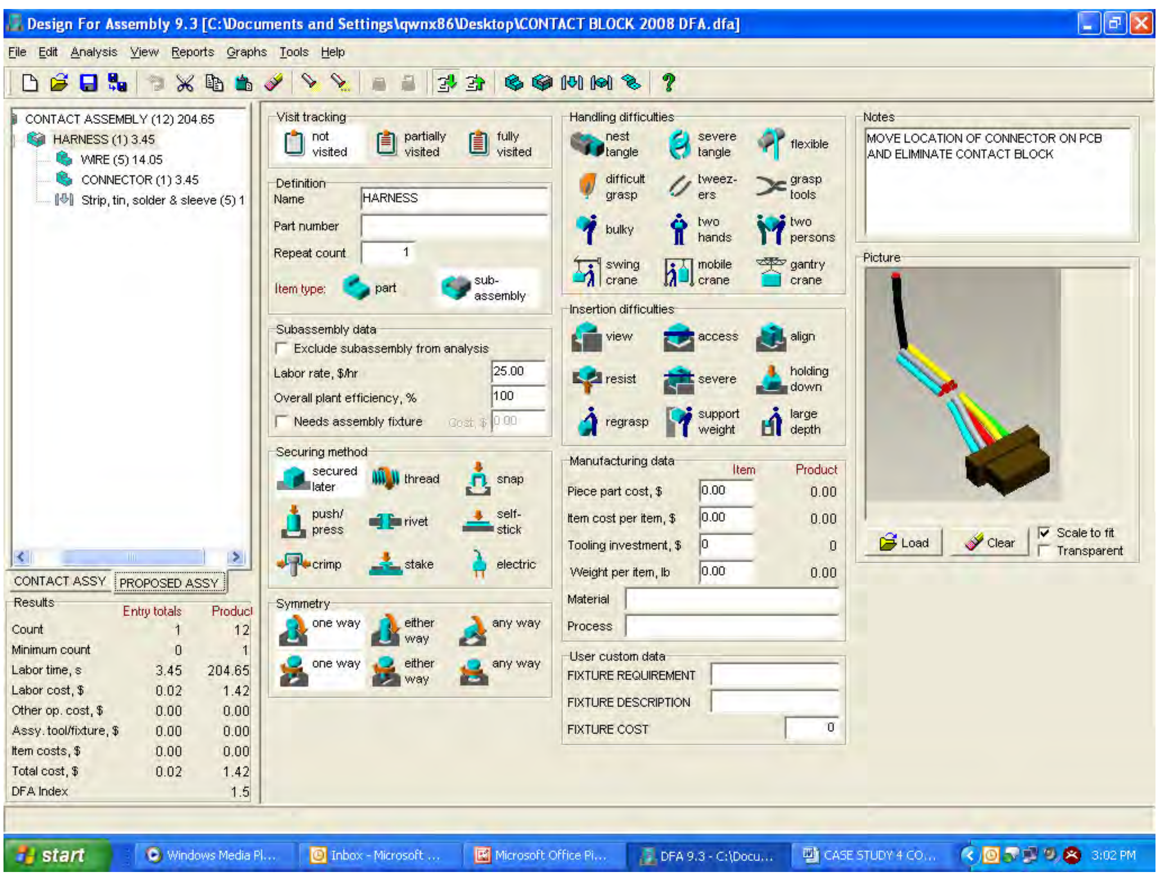
PROPOSED NEW HARNESS

CONNECTOR MOVED ONTO PCB





We performed the DFA analysis on the proposed new design eradicating the Contact Bock interface.



After performing the BDI DFA on the proposed changes, we then ran the Executive Summary comparing the two designs.

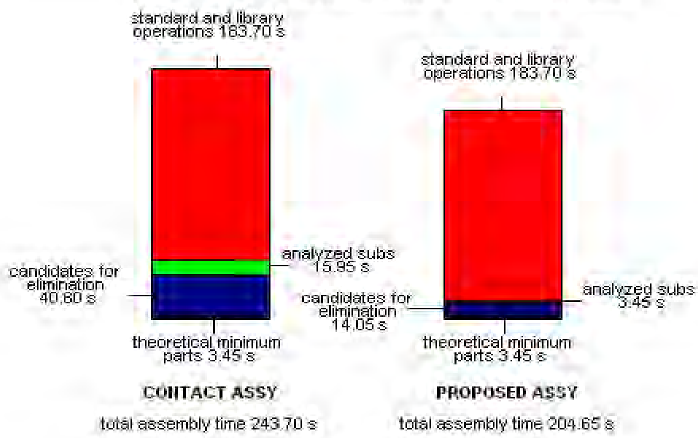
Executive Summary Comparison - DFA

MOTOROLA

Friday, May 16, 2008 3:01 PM
CONTACT ASSEMBLY

Per Product data		CONTACT ASSY	PROPOSED ASSY
Entries (including repeats)	Component parts	12	6
	Subassemblies partially or fully analyzed	2	1
	Subassemblies not to be analyzed (excluded)	0	0
	Standard and library operations	5	5
	Total Entries	**19**	**12**
Labor Time, s	Component parts	44.05	17.50
	Subassemblies partially or fully analyzed	15.95	3.45
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	183.70	183.70
	Total Assembly Time	**243.70**	**204.65**
Labor Cost, $	Component parts	0.31	0.12
	Subassemblies partially or fully analyzed	0.11	0.02
	Subassemblies not to be analyzed (excluded)	0.00	0.00
	Standard and library operations	1.28	1.28
	Total Assembly Cost	**1.69**	**1.42**

The chart shows a breakdown of time per product



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Comparing the two designs:

DESIGN TYPE	QTY OF PARTS	LABOR (SEC.)	PROCESS	DFA INDEX
USING CONTACT BLOCK ASSY.	19	244	1	1.3
NON-CONTACT BLOCK	12	204	1	1.5

By eliminating the Contact Block Assembly, we show a 36% reduction in our part count, the Labor time was reduced by over 16% and our DFA Index was improved by over 13%. There was also a product cost savings of approximately 50% for this interface assembly.

These savings did not include additional savings of NRE, additional Tooling and the cost of quality. These are all additional benefits of the DFA process.

Because of the timing cycle of reviews with the ODM/JDM, the design effort for the Contact Block Assembly was fully underway when it was presented to the Team. There was some loss in the design time cycle because of this elapse in reviewing cycles. If the design was performed in-house, this expenditure of time might not have gone on as far as it did.

After reviewing the proposed design and discussing a number of options, it was decided to go with the No-contact Block design. The effort was driven based on the out come of the BDI DFA review. This review removed any subjectiveness from the design.

These are just a few examples of successfully performing a DFA analysis using the Boothroyd Dewhurst software with a design from an outside design firm.

Pitfalls and Lessons Learned

First and foremost, what can go wrong by going “out-of-House’ - you lose some control of the design and design process, as previously stated. With a design done “inside” it is usually straightforward for the Design Team and Manufacturing Production Team to meet and discuss simple day-to-day aspects of the design. Small details can be handled effectively and do not become time-consuming details that grow up to become large, program-stopping issues. With an ODM/JDM, both formal and informal discussions have to be thought out and even in some cases scheduled for discussions or presentations.

Sometimes a simple phone call can be made and uncomplicated questions can be answered. This is not true in all cases. A simple thing like the discussion of banking features of a product may require specific CAD files to be shared between the two companies. Preparing the files for transmission, annotating the file with specific points to be discussed and then transferring them all take time and resources. This effort would then take time away from the ODM/JDM to work on the overall project.

So, what are some of reasons that an ODM or JDM design experiences the infamous “part -creep” we do not want to see in a lean design? That is, besides the obvious reason of not designing to well-defined manufacturing requirements. There are a number of other factors that could result in a mediocre design.

The chosen design firm may have very limited experience in designing your type of product or understanding your company’s design requirements. There is the possibility of having no history of actually producing the type of product in question. As an example, not all companies that work in the Optical fields can design a camera or an imager that is hand held and is cost effective. To design a hand held imager you must be familiar with numerous optical requirements, the cleaning requirements for the lens, weight requirements and overall ruggedness.

The chosen design firm may have limited manufacturing experience. Designing a product is one thing but, designing a quality product that can be consistently mass produced with a high yield is another story. You must remember that all design firms may not have Engineers with the manufacturing knowledge, understanding and experience that you need.

The ODM/JDM’s design department may not solicit feedback from their Manufacturing people (if they have them). Their design Engineers may be “CAD Junkies” that can design a product quickly but have little experience in designing for the manufacturing environment. Some companies may have Engineering departments that just “throw it over the wall” and wait until something gets thrown back. Not all companies have Engineers that embrace feedback from their Manufacturing people. This is a significant failure that is usually part of a company’s culture and may not be visible until the project is underway.

There may be no major incentives for the designer of the product to use the minimum amount of parts. Depending on the contract terms, for a dedicated design house it could be a fixed price to deliver, within a specified time frame, a working product design that meets certain specifications. The faster the design is released, the faster they can move on to the next project. So why spend time and effort on developing a snap design, for instance, when a Bracket and two Screws would work just as well?

Other agreements with companies to design and also build products for your company may include additional costs added on when the product goes into manufacturing. These could include supplementary costs tied to the product’s Bill of Material value such as an added percentage for managing it. The more costs you add to the Bill of Material, the more additional capital it could cost you in added support expenses. All of this is driven by additional parts in the original design.

Some of the other "hidden" costs when working with an outside design team could include:

a. How do they respond to specification creep, additional requirements and restrictions, testing issues? All part of a typical program that now a third party must respond to.
b. There is the possibility of incompatibility of design tools (CAD), MRP and document control systems, and test methodologies. All of these require additional resources to manage from both sides of a product.
c. In some cases there are time zone differences, and language and culture differences that can slow down a product's development.
d. Not all companies have the same level of priorities and sense of urgency.

The lesson learned from working with ODM/JDMs is that most of these partnerships are unique. The relationship the parent company has with their chosen design house is very critical to the success of the program. A very large degree of flexibility is needed on both sides to be able to adapt to ever-changing events that can come creeping into a program.

Some of the ODM/JDMs have design Teams that are very well versed in DFA, some do not. It is the responsibility of the parent company to identify, up front and early in the program, the Manufacturing requirements along with all of the Engineering requirements. The ODM/JDM must understand that having a lean design is expected of them. They should understand at the very start of the program that the design should be transferable to almost any high-quality production facility. A design that requires very unique process and systems is not as easily as transferable as a design that is simple and easy to assemble.

The benefits of using ODM/JDMs are not to be ignored. From helping to get a product to market early on, to supplying needed resources, the ODM/JDM model can be beneficial to all parties involved.

An ODM/JDM can bring in fresh new ideas to a stale environment. Their concepts may contain thoughts that your current Design Team had not researched or had already discarded because "we never did it this way in the past". This is the true value added by an ODM/JDM.

Summary

In this ever changing world in which we live today, more and more companies are outsourcing their design efforts as well as their manufacturing capabilities. With numerous outside companies performing more and more of a parent companies product design tasks, your success is ultimately tied in with the success of their design. These ODM/JDM partnerships are driven towards the bottom line, cost. This is why Designing For Manufacturing is so imperative. Using the Boothroyd Dewhurst's, Design For Assembly software is so important in helping drive the success of project by objectively identifying DFA concerns up front and allowing them to be addressed before they become an impediment to the project.