



# Using DFM to Improve Purchase Price Variance Within the Supply Chain

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## **Introduction**

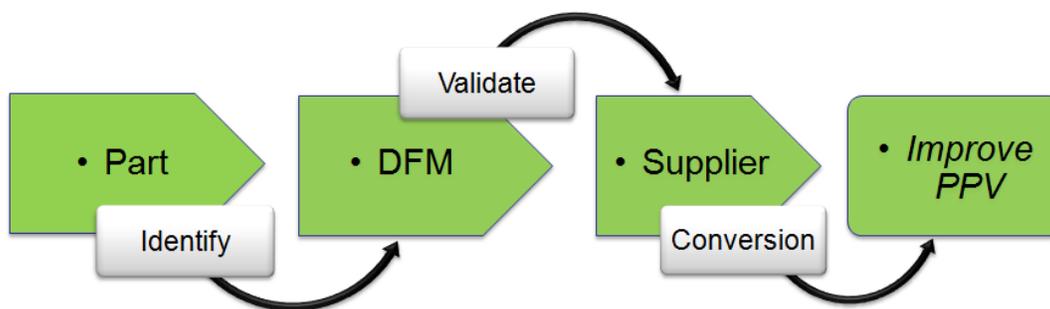
For twenty-nine years now, practitioners of Boothroyd Dewhurst's (BDI) DFMA software have shared examples of applying the tool for product costing and simplification at BDI's annual DFMA Forum. Applying the Design for Assembly (DFA) portion of BDI's software to the design of new products can result in large reductions to total parts in the assembly and total product cost. The second half of the software, Design for Manufacture (DFM), is typically used as a highly accurate cost-estimator of manufactured parts early in the design process. It is a common perspective in the DFMA community that applying the DFA portion of the software will provide a larger improvement towards product cost and ease of assembly than DFM. This author agrees with this perspective as well, but believes DFM can provide a substantial impact to a business when applied to existing part inventories within the Supply Chain.

Looking back at the number of papers that have been presented at the DFMA Forum, DFA has been linked with many engineering initiatives put into practice throughout the years. For example, initiatives such as Concurrent Engineering, Lean/Six-Sigma, and Value Engineering have been integrated with the use of DFA. Not to say that the topic of DFM for Supply Chain has not been covered through the years, it has, just in a lower volume of case studies.

Dynisco Instruments, manufacturer of sensors, controls, and analytical instruments for the plastics industry, and also a business unit of Roper Industries, has been a user of BDI's DFMA software for the past six years. During this span, Dynisco has fully implemented DFMA throughout its business. Like most DFMA practitioners, Dynisco has heavily focused on applying the software to new product development. In addition, we have developed an approach for using DFM pricing estimates to assist in improving the purchase part variance of our manufactured parts within the Supply Chain at Dynisco and other Roper business units. The following will outline the DFM process used to gather data on manufacturing costs for parts, which include supplier overhead and profit estimates, for total part pricing. How to approach suppliers with this data to assist in negotiating improved prices will also be reviewed. And lastly, a review of how to apply this same DFM cycle early in the new product development process concurrently with DFA.

## DFM Process

Dynisco first presented the DFM Process diagram, shown in Figure 1 below, at the 2012 DFMA Forum. This process outlines the steps to take in order to prepare DFM price data for discussions with suppliers on negotiating purchased part prices. The starting point is to take a manufactured part from the supply chain, along with its purchased price, and run a DFM analysis of the part to determine if the supplier pricing is reasonable. A side by side comparison of the standard price versus the DFM price will either validate the purchased price or show a gap in pricing. This is the “Identify” phase in the DFM cycle. Parts with differences between standard and DFM pricing identify the potential for a cost savings. The “Validate” phase can take on a couple of different meanings. First, DFM pricing that is approximately equal to or greater than will validate that the supplier is providing a suitable price for the part. Second, if a large price gap exists between the supplier and DFM price, this is where it is incumbent upon the DFM user to validate the accuracy of the cost model, as well as investigate the print specification of the part to determine design features and tolerances that can be defined as the cost drivers. The third and final phase of this DFM process, “Conversion,” is to use the data generated from DFM analyses and engage suppliers to negotiate lower prices for purchased parts. Essentially convert differences in price into savings.



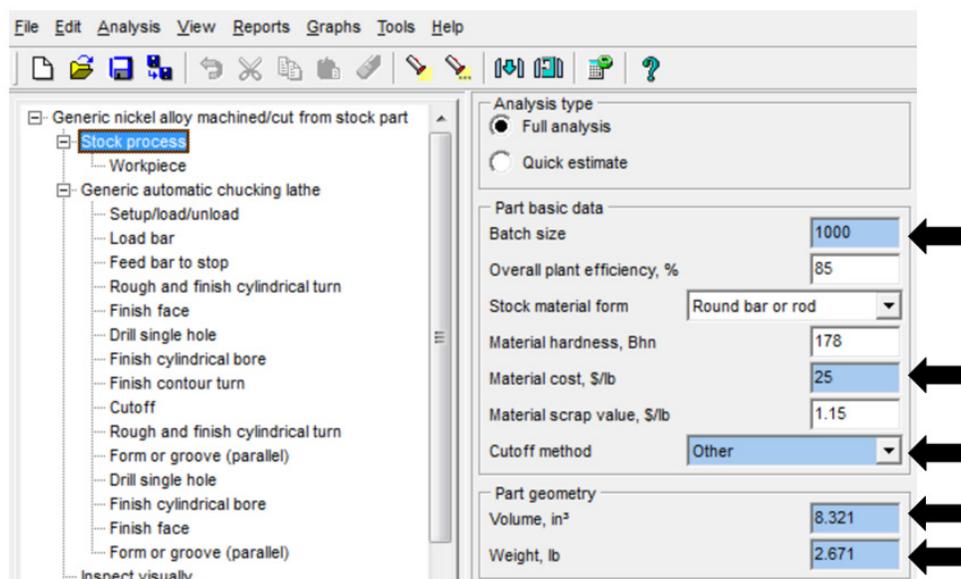
**Figure 1 – DFM Process: Identify, Validate, Conversion**

The starting point for using this DFM process is to gather a list of parts with the highest spends from within the Supply Chain. The Pareto principle can be applied here. Typically eighty-percent of the spend in Supply Chain will come from twenty-percent of the parts. This is simply gathering a list of parts with the standard price and yearly volumes for each part to determine the highest amounts of spend. Typically, Dynisco uses the part pricing and volume as well as the typical batch or lot sizes combined with the 3D model and part drawing to run the DFM analysis. The batch sizes are usually what quantity the part is purchased in by the Supply Chain each time production requires the part. Batch size is probably the single most important input required for an accurate DFM analysis. However, there are many inputs entered into DFM that will impact the accuracy of the model as the next section will define.

## Accuracy with DFM

BDI's DFM software can generate should-cost data for a large number of manufacturing processes and material combinations. The software will break down the cost to manufacture the part into the following areas; material, setup, processes, rejects, and tooling. A custom operation can be added to DFM to calculate supplier overhead costs as well as their estimated profit or margin per part. This custom DFM operation is built so it will ask the user to input a percentage for overhead and profit. Adding in the overhead and profit to the cost to manufacture the part can be considered the total "price" of the part.

For reviewing the DFM input steps, a part machined on a lathe will be used as an example. Once the approximate envelope dimensions are entered into DFM and the process and materials are selected, DFM will first assess the material costs for the part. The batch (lot) size is now entered into DFM (Figure 2). The batch size will have the most impact on the setup cost for each machine used to process the part. This will also impact any special costs amortized across the volume of parts such as tooling, fixtures, or programming. The cost per pound of the raw material can also be entered into DFM. The software provides these costs as defaults for more common materials such as steel or aluminum. The exact cost per pound can be adjusted if known from the supply base or when using exotic or expensive materials such as Inconel which can cost anywhere from \$22 to \$30 per pound depending on the grade used. Rounding out the critical inputs for estimated material costs, are the volume and weight of the final part geometry. The work piece is defined as the envelope dimensions of the stock geometry of the material being machined to ensure there is "extra" material to start with before machining begins.



The screenshot displays the DFM software interface. On the left is a tree view showing a hierarchy of manufacturing processes for a 'Generic nickel alloy machined/cut from stock part'. The 'Stock process' is selected. The main window on the right contains input fields for 'Part basic data' and 'Part geometry'. Black arrows point to the following fields:

Field	Value
Batch size	1000
Overall plant efficiency, %	85
Material cost, \$/lb	25
Volume, in <sup>3</sup>	8.321
Weight, lb	2.671

Figure 2 – Material cost in DFM

Once the stock process for the material is defined, the user defines what machines are used to process the part. The DFM software contains a database of various machines to be assigned to the analysis. For this example part, a generic CNC turret lathe is used. Under the setup/load/unload row for each machine used in an analysis (Figure 3), the number of part reversals (how many times a part is moved within the setup), setup time, and again, tooling, fixtures, or programming can be entered in this row. Machining processes are then entered from the wealth of different operations within DFM’s Operations Library (Figure 4). The machining operations can be defined by entering dimensions for material removal. This data can be easily calculated by using the part print and starting work piece geometry. Reject rates are entered as a percentage for each machine selected for a DFM analysis.

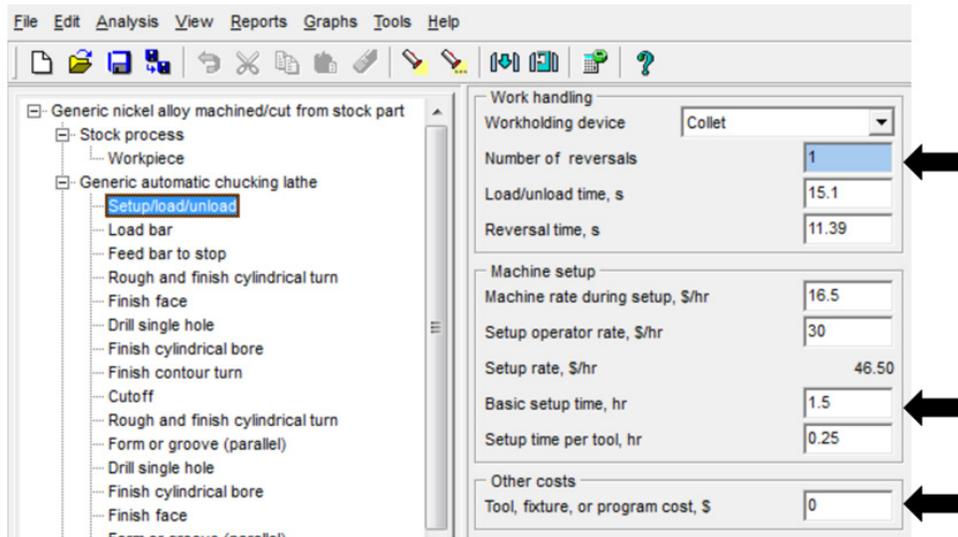


Figure 3 – Setup cost in DFM

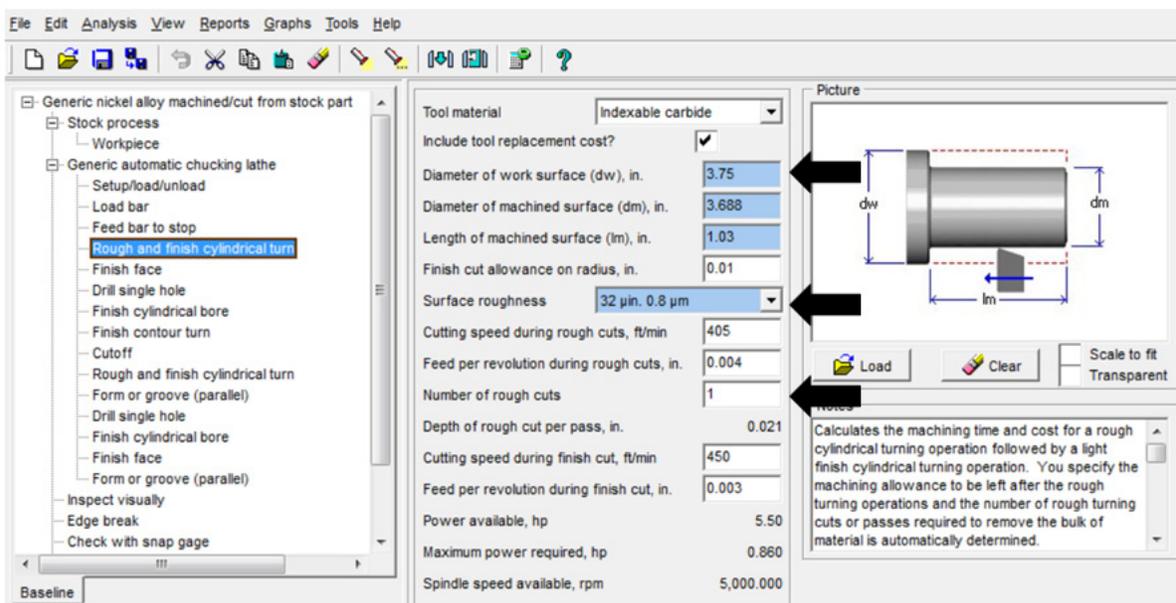
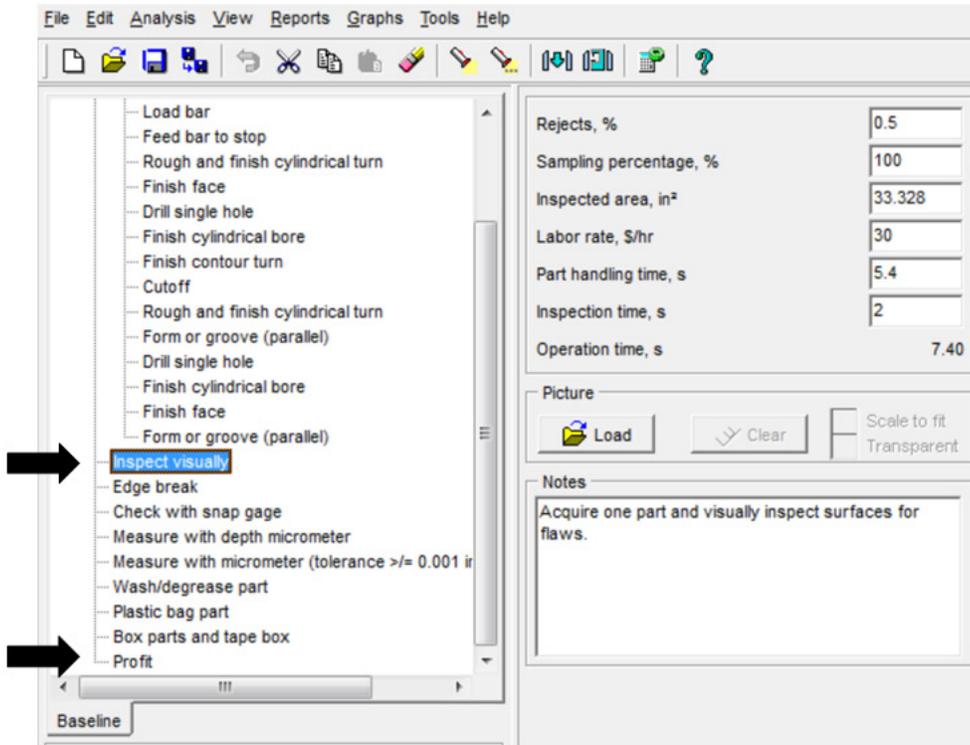


Figure 4 – Processing cost in DFM

Extra operations such as inspection, measurements, and cleaning of parts should be used consistently throughout the analysis exercise. While these smaller operations will add minimal costs to the part price, it's good practice to show suppliers the level of detail used in creating DFM analyses during discussions on part price. Additionally, and more importantly, if a part has finish requirements such as heat treatment, plating or painting, those can be added as well. Shipping requirements such as bagging and boxing of parts should be considered also. Lastly, supplier overhead and profit should be taken into account to complete a full DFM price analysis (Figure 5).



**Figure 5 – “Extra” operations in DFM**

Once the DFM analysis is complete for a list of parts from the Supply Chain, there are multiple ways to prepare pricing results for discussions with suppliers and internal presentations. The DFM software offers reports that can be exported from the software such as an Executive Summary, a Results Summary, and a Totals Summary. Dynisco’s preference is to use the Results Summary. The Results Summary gives a line-by-line display of every operation in the DFM analysis while breaking down the processes time and cost for each. This summary provides the ability to match the operation or machining process to the equivalent dimension on the print. This can be done by numbering the operations and adding matching numbered balloons near the dimensions on the print, similar to a First Article Inspection Report.

## **Design Intent**

Another step to take during the DFM analysis is to review the engineering specifications of the manufactured part with a thorough review of the part drawing. Dynisco's VAVE group has performed over a thousand different types of DFM analyses for the different companies and business units within Roper. These DFM analyses range from machined parts, castings, forgings, and plastic parts across multiple product types and industries. The lesson learned from reviewing these parts, is that it is important to keep manufacturing process capabilities and proper material selection in mind during the design process. Most companies deploy the use of 3D modeling to develop products. The power of 3D software packages is that they allow the design engineer to model pretty much any shape that they can imagine. It is important, however, to keep stock material sizes as well as alternate processes and materials in mind during the design process. This means, in some instances, that just because it can be modeled, it doesn't mean it can be machined and be a cost effective part. There must be a balance between the geometric features of the part that creates its function or design intent and the manufacturing processes capable of producing said geometry.

In addition to designing or "modeling" for manufacturing, proper tolerancing and application of Geometric Dimensioning & Tolerancing (GD&T) are critical to produce cost effective parts. Again, the power of the 3D software can sometimes contribute to tolerances that adversely impact cost. How many of us work at companies where drawing title block templates are built into the 3D software for easy drawing creation? Typically, once a model of a part is completed, an engineer, designer, or drafter will begin creating the drawing by importing the necessary title block to start the drawing file. Most title blocks will have a generic block for tolerancing that usually states "unless otherwise specified" and then defines the tolerances for dimensions at two or three decimal places. In some cases, the dimensions pulled into the drawing from the CAD model are not thoroughly reviewed, leading to tighter tolerances than the part requires. Other times, drawing dimensions can be over toleranced and GD&T applied too liberally. Many machining operations in DFM ask the user to specify the surface roughness being machined. The DFM software equates surface roughness to approximate tolerances, which in turn, directly relates to the amount of processing time required. Processing time translates into the manufacturing cost. The message is to be aware of how tolerances can impact cost as shown in Figure 6.

## Tolerance (machining)

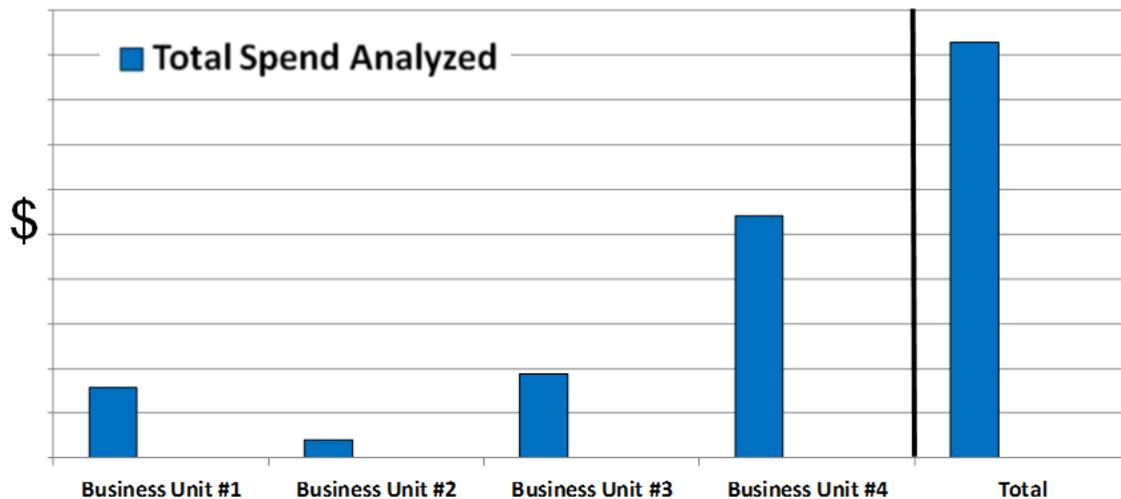
Surface Roughness		Approximate Tolerance	
Microinch	Micrometer	Inches	Millimeters
4	0.1	0.00015	0.004
8	0.2	0.00025	0.006
16	0.4	0.0004	0.01
32	0.8	0.001	0.025
63	1.6	0.005	0.13
125	3.1	0.01	0.25
250	6.3	0.04	1.0

= Processing = \$  
Time

**Figure 6 – Chart from the DFM software equating surface roughness to tolerances. Part prints should be reviewed during the DFM process to understand how tolerances drive processing time and in turn, impact manufacturing costs.**

### Supply Chain

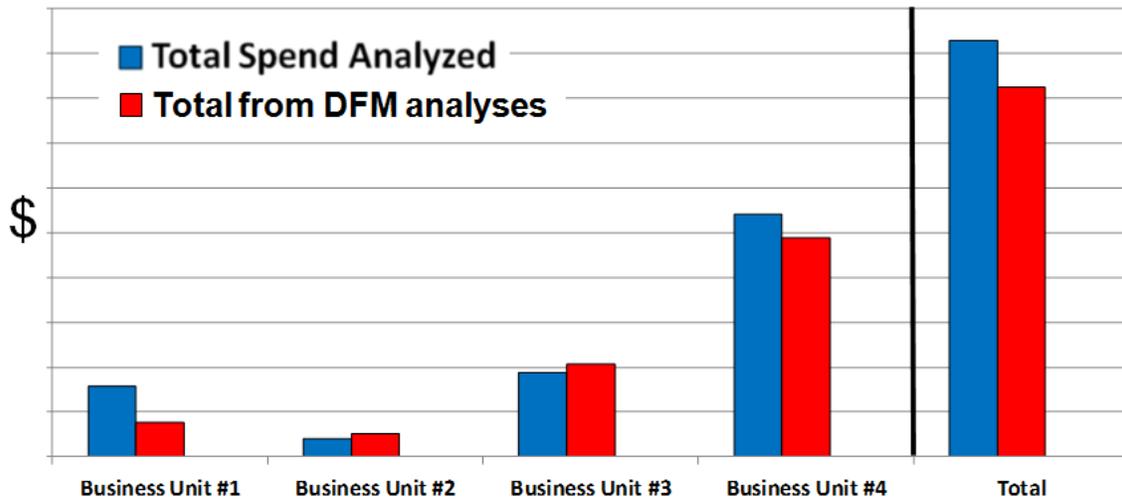
Once the DFM analysis has been completed for each part provided by the Supply Chain group, the focus now turns to engaging the supplier. The following example will use the total spend on approximately 350 parts across four Roper business units from 2013. To start, the parts list with standard purchase price and yearly volumes have been prepared. The total spend on DFM analyzed parts from each business unit will look like the chart in Figure 7.



**Figure 7 – Total spend on manufactured parts within the supply chain at four Roper business units.**

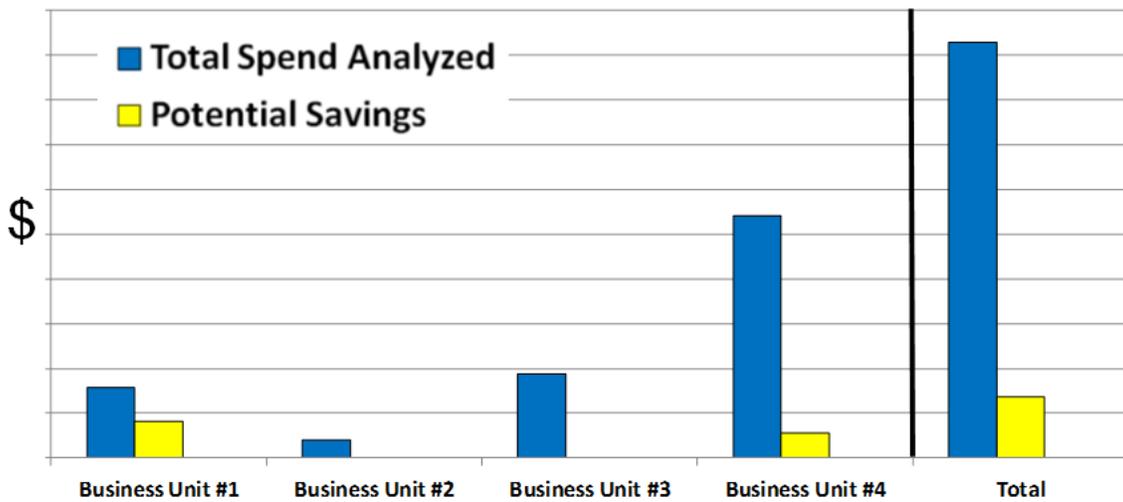
The DFM analysis prices are then multiplied by the same part volumes and compared to the standard cost total spend. This shows where differences are between standard and DFM prices and where the opportunities are for potential cost savings (Figure 8). The DFM prices were higher than standard at

business units #2 and #3. In this case, the DFM analyses are “validating” suitable pricing for parts at these two sites.



**Figure 8 – Total standard cost spend from the Supply Chain compared to the DFM price totals.**

Another way to look at the areas for potential savings is shown in Figure 9. The yellow bars show the opportunities for potential cost savings against the total spend on the parts. In this example, DFM prices were collectively 52% lower at business unit #1 and 10% lower at business unit #4. These are the parts that require discussions with the suppliers who provide them.



**Figure 9 – Potential savings at business units #1 & #4.**

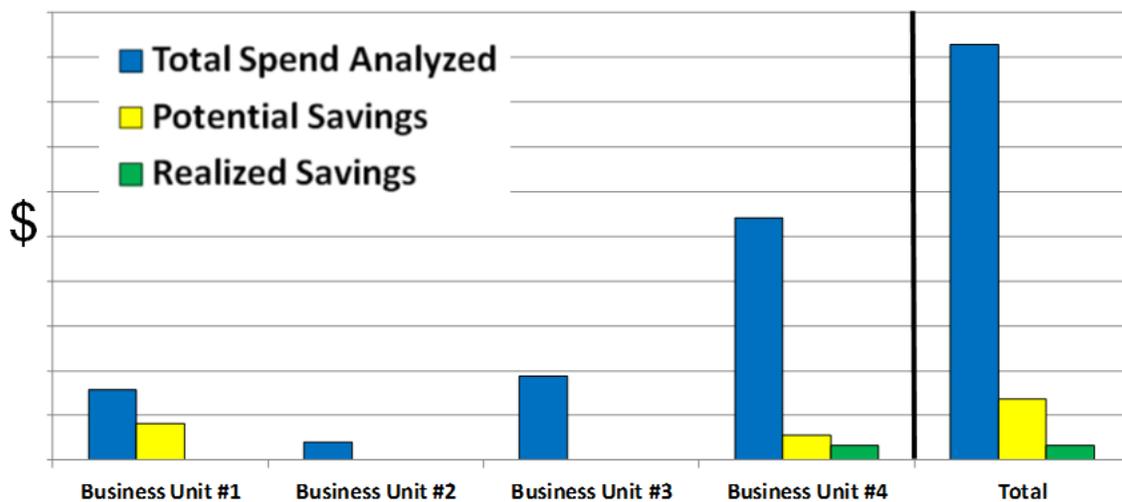
### **Supplier Engagement and Results**

After completion of the DFM analyses from the Supply Chain parts list, the next step in the DFM process is to prepare all of the DFM data on pricing and set up meetings with suppliers to engage in discussions about price. The approach we try to use with suppliers is one that is non-adversarial. Discussions on part

price between two businesses will always be a delicate topic. There has been apprehension from suppliers and buyers when discussions get to the level of detail on price that DFM requires. The best way to alleviate the apprehension is to clear the air and state that the goal of the meeting is to determine what is driving the cost of the parts being reviewed. Another part of the approach that Dynisco has taken has been to be as open as possible with the DFM software. One technique that has been deployed is to open a DFM file on the overhead projector in the meeting. Showing the supplier what assumptions were made to build the DFM analysis and asking for their input will bring the supplier into the discussion. In most cases, the supplier will contest some of the inputs that have been entered into the software. Our response has been to accommodate them and make adjustments to the DFM inputs on the fly, recalculate the DFM analysis, and determine how the changes impacted the pricing results. Additionally, asking the supplier for their suggestions on how to improve manufacturing cost will bring the supplier into the discussion further.

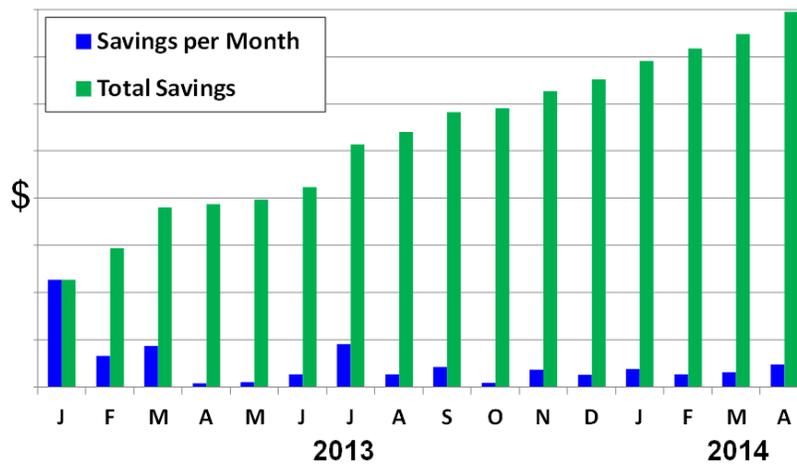
There are a couple of benefits that are accomplished by using this approach. First, engaging the supplier in a non-adversarial way and asking for their input will create the sense of partnership between the two sides. Second, the implied message in this process with DFM is it lets the suppliers know that there is a concentrated effort on the consumer side to focus on part pricing without ultimatums. Using a data driven approach for pricing with DFM can provide better results for cost savings than mandates from management to the supply base.

Figure 10 below shows the cost savings results for 2013 at the four business units being examined. The bar in green represents the value of improved purchased price variance at business unit #4.



**Figure 10 – Realized savings at business unit #4 shown in green.**

The scale of the chart in Figure 10 does not pictorially justify the results that were accomplished. By diving down to a smaller scale and displaying month to month results shown in Figure 11, it illustrates that a realized savings was accomplished each month of 2013. Additionally, that steady stream of cost savings continues into the first four months of 2014. These results are directly related to conducting meetings with suppliers as previously described. The partnership between business unit #4 and a key supplier was solidified. Because of the willingness to participate in the DFM program, this key supplier is now being presented opportunities to quote parts from other business units.



**Figure 11 – Monthly and total savings at business unit #4 through improving the purchased price variance on manufactured parts within the Supply Chain.**

**Summary**

Dynisco’s DFM process has yielded cost savings for the business through improving the purchase price variance on manufactured parts as well as validating supplier pricing on other parts. Applying the DFM software to parts within the Supply Chain will assist in identifying opportunities for potential savings, validate suitable pricing from suppliers, and provide the proper data to engage suppliers to aide in negotiations on part pricing. These results come through the collaboration of many departments in the business and engagement from key suppliers. This DFM process outlines an approach that companies can take on products currently being produced from legacy parts within their Supply Chains.

What happens when you complete a DFM analysis on every possible part within the Supply Chain? A Dynisco buyer recently proposed this question. The answer is to take this DFM process and, if not being applied already, apply it to new products being developed with DFA as both pieces of the software are intended. Once a program with DFMA like this is established, a business can be confident that pricing for

every manufactured part in its Supply Chain has been thoroughly reviewed with DFM. Additionally, every new product released has been optimized with DFA for cost and ease of assembly with every manufactured part analyzed with DFM to be cost effective. As previous DFMA Forum papers have alluded to, DFA does identify larger opportunities for cost improvements for a business, just don't forget the 'M' in DFMA. It can be just as powerful.

### **References**

1. Boothroyd Dewhurst, Inc. *Design for Assembly 9.4*©. *Design for Manufacture: Concurrent Costing*©.
2. Boothroyd, Dewhurst, Knight. *Product Design for Manufacture and Assembly*. New York: Marcel Dekker, 1994. 0-8247-9176-2.