# DFA Suggestions for Redesign: What to do with all those Candidates for Elimination within the Product?

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## Introduction

The Design for Assembly (DFA) software by Boothroyd Dewhurst, Inc. (BDI) is a product development tool that assists engineers with simplifying their product designs through part count reduction. This is done by using functional requirement questions on each part within the product design to determine which parts are candidates for elimination and which are required parts that provide product function. For engineers that are new to DFA, the intent of the minimum part criteria questions can be interpreted with multiple viewpoints. For example, these questions can sometimes be answered quickly without a full discussion about the part function or some may try to eliminate all parts deemed candidates for elimination in the DFA analysis. Most products analyzed with DFA will in fact provide plenty of candidates for elimination and opportunities for engineers to simplify their product design and reduce costs. This paper will review a DFA analysis to show how to generate suggestions for redesign and how to approach parts identified as candidates for elimination. A completed baseline DFA analysis and redesign workshop on an example product will be used to offer suggestions on how to interpret the minimum part criteria questions and identify which candidates for elimination are ideal for starting the redesign process. Part function within the DFA analysis will also be stressed in this example.

## Common Views to DFA

Whether a company has experience with using DFMA (Design for Manufacturing and Assembly®) or is just beginning, the multiple-day workshop offers the best setting for application. A multiple-day DFMA workshop typically consists of a cross-functional team in a sequestered setting. The team reviews the product from the DFA perspective, which is to examine each part within the product design.

As a facilitator of multiple workshops, this author has seen consistent responses towards DFMA. The software is intuitive as users understand the required inputs and outputs of DFA specifically. There are two ends of the spectrum when it comes to answering the minimum part criteria questions, either part types are quickly assigned without enough discussion on part function or too much time is spent categorizing a part that can stall the flow of the workshop. A middle ground is suggested here, but also leans towards more discussion. The minimum part criteria questions are essentially asking the team to define the part function. Does the part fasten or connect other parts? Does is move relative to all others? Must it be a different material? Or does it need to be separate to allow assembly? DFA poses these questions to get the team discussing what type of part it is; a candidate for elimination or required for function.

Once a DFA analysis is completed on a product, interpreting the data collected by DFA can also be a challenge in pinpointing how to approach a product redesign. There are multiple reports that can be exported from the DFA software. Each provides different data or ways of viewing the product. For example, DFA can yield summaries on candidates for elimination, assembly time, handling/insertion difficulties, part type paretos, and even parts categorized by function groups. These reports are commonly used for the report out to management at the end of a workshop, so it is important to determine what provides the proper information to recommend the next steps for the project.

Engagement level from the workshop attendees also factors into the DFMA process. And that can also depend on an individual's background. Most mechanical engineers, for instance, naturally gravitate to the DFMA process as the focus is on how the product assembles, while electrical engineers, product managers, or those in management may not be at the same level in regards to knowing the product assembly. However, it is important to have different perspectives from various disciplines to provide insight into the product that the mechanical engineers may not have. Contributions from a cross-functional team can have a positive impact towards the end results of the workshop.

**Candidates for Elimination**

Preparing for the DFMA process in a workshop setting can be started by an individual or a few team members. DFA specifically begins with the entry of a product bill of material into the software. The parts within the bill of material are next organized into the best-known order of assembly. Assembly operations can be added as well. Each part is then examined with the minimum part criteria and handling/insertion difficulty questions. The DFA software will estimate the labor time of the entire assembly and provide ease of assembly data for the user.

The key to the DFA process is to understand that the minimum part criteria questions should be viewed as understanding the function of each part. What function does the part provide within the assembly? For each part, you'll be asking the following questions for each part:

- Is its function to fasten other parts together?
- Is its function to connect other parts together?
- Does the part move relative to all other items?
- Must the part be a different material?
- Must the part be separate to allow assembly?

Parts that fasten and connect are automatically deemed candidates for elimination once assigned in the software. Parts other than fasteners or connectors that do not meet the remaining minimum part criteria questions are designated as category 1 candidates for elimination. Once a DFA analysis is complete, the user can select the redesign button in DFA to show the three suggestions for redesign categories. Category 1 candidates should be the focus as these parts typically carry the most weight towards costs than categories 2 and 3, which are fasteners, connectors, separate operations, and handling/insertion difficulties. While engineering teams should be conscience of category 2 and 3 candidates, focusing on category 1 candidates will usually impact and improve upon categories 2 and 3.

If a product development team has never applied DFA before, the results of the analysis will show opportunity for design improvements. This should not be viewed as a negative reflection of the product design or efforts of any design team. DFA just provides an alternative way of assessing the function and value of each part within the product design. As an example, Figure 1 shows a pareto from a completed DFA analysis where the count for each minimum part criteria category is shown. This can also be described as a "part count by part type" pareto. It shows that 84% of the parts within the assembly are candidates for elimination. This should be viewed as an excellent opportunity to reduce part count in the product by eliminating parts or combining them with required parts for function. It is well documented that part count reduction has many benefits, such as improving ease of assembly, cost reduction, labor time reduction, quality improvement, and reliability improvement, for example.

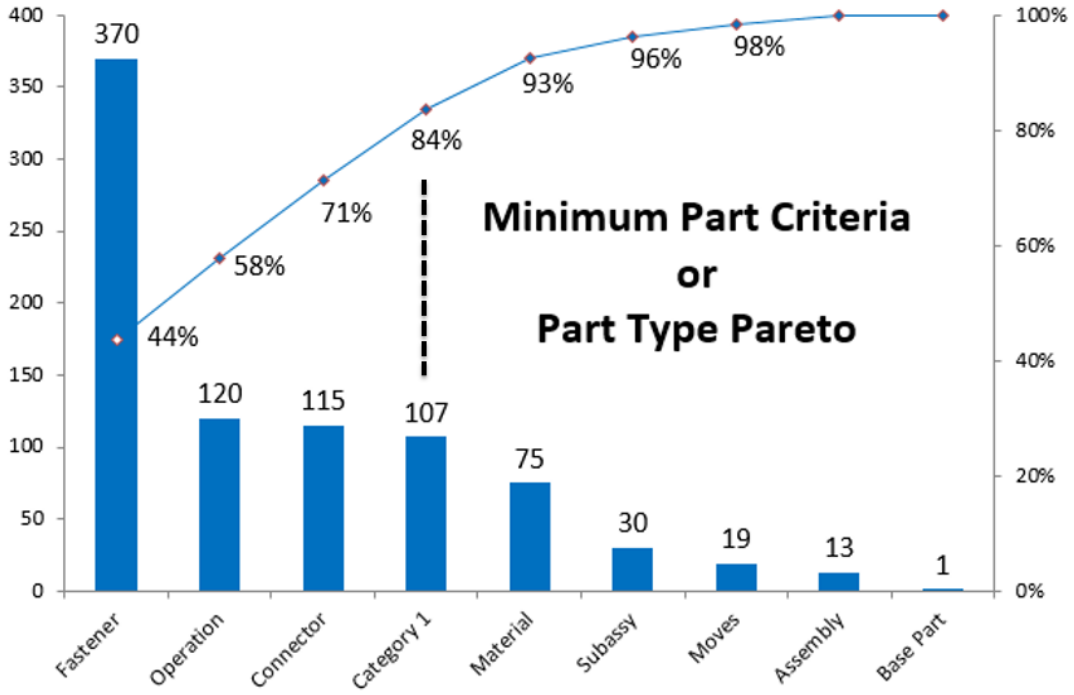



**Figure 1 – Example of a post-DFA analysis pareto based on part type.**

Additionally, Figure 2 shows the average part type percentages from ten different DFA analyses completed by Dynisco's VAVE (Value Analysis/Value Engineering) group. The VAVE Group has completed many DFA analyses over the last few years and ten were selected at random. The products analyzed are market leaders from multiple industrial markets. Many different products and companies are showing an average of 80% of the products parts are candidates for elimination based on the DFA results. Again, this should be viewed as an opportunity for product enhancements.

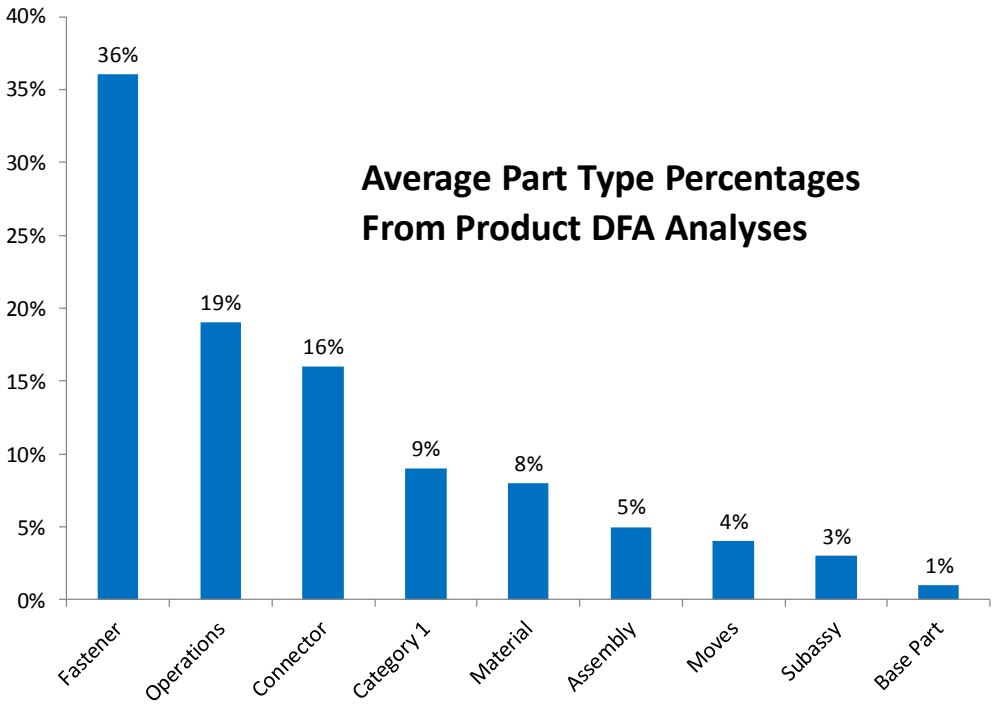



**Figure 2 – Pareto showing the average part type percentages from Dynisco VAVE Group DFA analyses.**

## DFMA Workshops

To review how to answer the minimum part criteria questions and generate discussions, a workshop completed by Dynisco's VAVE Group will next be studied. While the product itself cannot be described in detail or shown, the example product assessed in figure 1 will be used for the discussion. To prepare for the workshop, the VAVE Group completed the initial DFA analysis as well as completing DFM should-costs on numerous parts within the assembly. A multiple-day workshop was arranged where a cross-functional team was to review the DFA and DFM data to generate ideas for cost reduction. Always helpful in a DFMA workshop is having the product in the room so the product and parts can be examined for the discussion. For this workshop, the product assembly was made available for the team.

The product itself has over seven-hundred parts and is a table-top instrument that analyzes material properties at elevated pressure and temperature during processing. The product has an aluminum extrusion frame that a 1.25" thick aluminum table plate is mounted to creating the main structure. The product is powered by 120 or 230 volts. There are a variety of part types within the assembly, such as sheet metal, plastic, electronic, and pneumatic types. The first step in the DFA analysis was to assign the base part. In this case, the table plate was assigned as the base part. The table plate was the first part entered in DFA under a subassembly simply labeled "frame subassembly." An alternative to this setup would be to include the aluminum extrusion frame and table plate together as an un-analyzed subassembly. This still would require the unanalyzed subassembly to be selected as the base part via the radio button in DFA. The base part is in theory, the part that all other parts in the assembly can be connected to per DFA.

Each successive part in order of assembly is then asked the minimum part criteria questions. Starting first with the item function questions of whether the part's sole purpose in the assembly is to fasten or connect. Fasteners are probably the easiest part type to identify. Screws, nuts, and washers fall into the fastener category. Perhaps the most recognizable type of connector is a sheet metal bracket. A type of part that houses other parts or connects two or more parts. On the example products, there were plenty of fasteners identified and the best example of a connector was in fact a sheet metal bracket that housed a fan for internal cooling as well as the power module and electrical connectors. It is important to debate the part function when asking the minimum part criteria questions. For example, one individual on the workshop team may quickly assign the sheet metal bracket as a connector, while another viewpoint may suggest that it is separate to allow assembly or does not meet the minimum part criteria and is assigned as a category 1 candidate of elimination. Discussion is the goal with the DFA process.

The three core minimum part questions follow for each part if the item function is not to fasten or connect. Parts that move relative to all other parts in the assembly are required parts. A part that moves on the example product was a plexiglass shield as it moves up and down in the assembly to protect the user from a pinch point in the assembly as well as a high-temperature, burn risk area. This is an interesting part to consider as it might also meet the material and assembly questions in DFA. It is a different material as the clear plexiglass allows the operator to view the material sample area. It also could be a part that is separate to allow assembly. Any of the selections in DFA would result in the plexiglass shield being deemed a required part in the product.

Assigning parts as meeting the "must be a different material" requirement can at times be the trickiest of the minimum part criteria questions. Electronic parts are commonly selected as being required due to its material. In the example product, parts that met this requirement were the printed-circuit board, the electronic touch screen for operator interface, the electric motor, pneumatic cylinder, and a high temperature seal.

For parts that are separate to allow assembly, covers are the most common type of part that meets this criterion. Industrial and consumer products commonly have covers that protect internal components. A recommendation in general for separate to allow assembly required parts is to use sound engineering judgement to assess the order of assembly and determine which parts could not be assembled if not designed separately. For the example product, sheet metal covers are used in many areas of the material analyzer and were assigned as separate to allow assembly. In some cases though, a few covers were also assigned as category 1 candidates for elimination.

The example parts of each of part types assigned with DFA have been reviewed. During a DFMA workshop, this is the process to use to discuss how the part functions in the product. It is also the time to generate ideas for alternative product designs. DFA has a notes section for each part where ideas can be typed in and recorded while the discussion is taking place. Again, this can be described as the goal with DFA and that is to discuss the function and value that each part brings to the product, as well as develop redesign ideas.

**Identifying Category 1 Candidates for Elimination**

But what about the parts that do not meet the three main minimum part criteria questions and do not fasten or connect? Part types like this are categorized as category 1 candidates for elimination. These are the parts where the most discussion should take place about how can they be eliminated or combined for function with required parts. Two parts from the example product that stood out in the DFMA workshop are next reviewed.

The first category 1 part to examine was an extruded aluminum profile section. This part is shown in figure 3. The extrusion is mounted to the top of the table plate with two mounting screws inserted from the bottom side of the plate. It is secured at the top of the extrusion with screws that tie it to the air cylinder mounting plate. Viewing the extrusion without the eyes of DFA on it, the extrusions function can be described as a support part that ties two plates together. While it offers minimal structural support,

additional functions it provides are contributing to aesthetics, it also allows other parts to be assembled to it, and the hollowed areas in the profile are used to run air hoses and electrical cables through and protect them. However, when viewed through the eyes of the DFA minimum part criteria questions, it does not meet them. And the extrusion was not viewed solely as a connector. This was the discussion that took place during the workshop and in the end, the extrusion was labeled as a category 1 candidate for elimination. An excellent example of how to handle the DFA discussion in a workshop setting and one that ended up targeting a part that carried weight in cost within the product assembly.

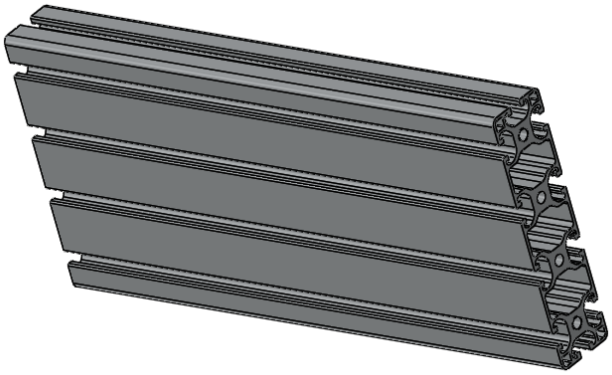


**Figure 3 – Category 1 part - Extruded aluminum profile.**

Another good category 1 candidate for elimination that was found during the workshop can be described as a machined aluminum shaft. There are two shafts used in the product, and they screw into the top of the air cylinder. The top cover is retained and supported by the shafts with screws inserted into tapped holes on the top surface of the shafts. As these parts were discussed, labeling them as connectors was certainly an appropriate designation within DFA. Either way, connector or category 1, the shaft would be a candidate for elimination. In the end, the team agreed to assign it as a category 1. This discussion led to alternate ways to support the top cover and if the shafts were required at all.

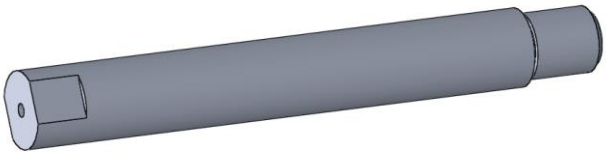


**Figure 4 – Category 1 – machined aluminum shaft, quantity of two per unit.**

The extrusion and the shaft parts show the essence of performing a DFA analysis as a group and the discussion that follows. Two parts that were designed with functional intent, are manufactured and

sourced to a supplier, and carry weight in cost to the product, are now being considered for elimination or redesign to lower the product costs without impacting overall function.

**Converting DFA Ideas into Redesign Concepts**

Over the course of a DFMA workshop a team should ensure that all the ideas generated are captured. A common practice at the end of a workshop is to provide a report out to management to summarize the findings. Once the ideas are captured using the notes section, a common approach used in DFMA workshops is to put the ideas into categories labelled safe, reach, or stretch. Safe, reach, or stretch ideas define the level of risk for the redesign idea. DFM is used during the workshop to measure the impact to cost for parts and when combined with DFA redesigns, the overall cost of the product. Lastly, a basic return on investment estimate should be calculated at the end of the workshop for the report out. The report out to management is done to show the opportunities that the team has found over the course of the multi-day workshop and to transition to how to implement the results.

Figure 5 shows the summary of the DFMA workshop conducted. It is common to see several redesign ideas captured and insight into how the team conducted the workshop. In addition to previous workshop recommendations, it can also be helpful to invite those who assemble the product or suppliers who supply parts for the product. Their input can be valuable as assemblers and suppliers have a different viewpoint towards the product and parts.


**Figure 5 – Summary of the results and activities from the example product DFMA workshop.**

From this multiple-day workshop, there were 38 redesign ideas for the product. Specifically, ways to eliminate category 1 or address them in redesigns such as the extrusion and shafts. Alternate frame and cover design ideas were generated in the workshop. DFM played a large role in measuring the impact of the suggestions for redesign as well as looking at the costs for functional parts that did not change.

**Workshop Results**

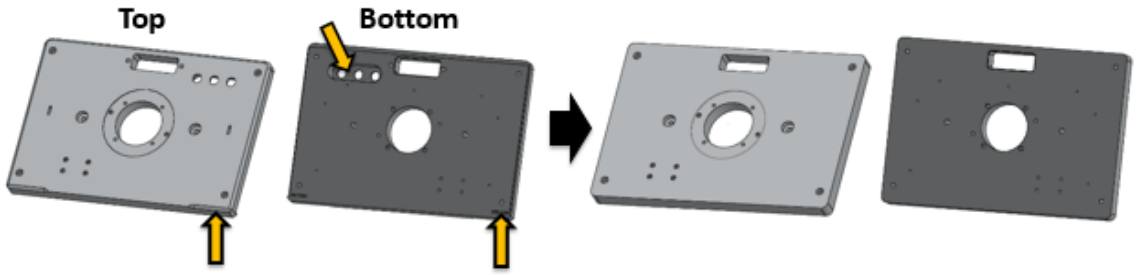
The next steps after a DFMA workshop is completed is to develop the implementation plan for the ideas generated by the team. As mentioned, categorizing the ideas into safe, reach, and stretch describe the amount of risk and engineering involvement necessary to vet the ideas before implementing. Safe ideas are low risk and can be immediately implemented. Reach and stretch ideas will take different levels of engineering involvement to mitigate the risks before implementing to production. It is recommended that any redesign be measured to the existing design in terms of "as good as, if not better." To do this, the category 1 candidates for elimination will be the focus. However, there will be ideas to improve the product in many different areas. Such as the design of the parts themselves, assembly improvements, using the DFM should-costing process, and it is important to note that even functionally required parts may be impacted.

For example, the table plate used on the product for discussion will be examined. Coming out of the DFMA workshop that VAVE Group conducted, there were ideas that could take machining costs out of the table plate. This was the first part examined in the assembly. In DFA it was designated as the base part from the minimum part criteria questions, therefore making it a required part.

The table plate was not a focus for changes until the redesign ideas started to flow. A large quarter-inch chamfer on the top edge of the parts is machined in for aesthetic purposes. The question was asked, was this required by the customer or functionally by the product? Additionally, on the bottom side of the plate, small grooves are machined along the entire bottom edge that mate with the exterior covers. While this provides a clean, cosmetic look, the question was again asked if this was required as well? Lastly, one of the design ideas from the workshop was to relocate three electrical connectors that are currently mounted on the plate. To mount the connectors, a rectangular pocket is milled into the bottom of the plate followed by machining three large through holes into the pocket as the opening for the three connectors.

Since this is a low-volume product, the cost of the base plate is in the hundreds of dollars' range. The first item reviewed was the DFM should-cost of the base plate. In the case of a part like this, there are options the team can take. Since the DFM should-cost was 19% lower than the actual supplier cost, the team could use the DFM data to re-negotiate the price with the supplier without design changes. They could move ahead with the changes and eliminate the machining of the large chamfer, the slots for the covers, and the pocket milling and holes for the connectors. The DFM should-cost on this proposed

design was an additional 8% lower when compared to the DFM should-cost of the existing design. This is a good example of how redesign ideas will impact functionally required parts as well as the candidates for elimination.




| Existing Supplier | DFM Analysis | New Design DFM Analysis |
|---|---|---|
| Baseline | -19% | -27% |

Proposed Design From Workshop:

- Remove Large Chamfer
- Remove Slots For Covers
- Remove Pocket Mill And Thru Holes For Connectors

**Figure 6 - Base plate DFM analysis for the existing design and post-workshop proposed design.**

**Summary**

To answer the question of what to do with all the candidates for elimination within the product, let's review. Performing DFA analysis on a product is about finding opportunities for improvement. Finding candidates for elimination with DFA is not about being critical towards the product design, it is about an opportunity to simplify. It must be understood that not all candidates for elimination can be eliminated, but the goal in a product redesign with DFA is to show improvement through minimizing part count by eliminating unnecessary parts to simplifying the product assembly. DFMA workshops are an excellent setting that promote discussions to generate innovative ideas towards product improvement. Changes to parts that are candidates for elimination will impact the design and cost of a product, but changes to functionally required parts will occur as well. It is also important to measure the cost impact from redesign and this is where DFM integrates into the process. DFM can offer ways to investigate the costs to using alternative processes and materials used for part redesign. Together DFA and DFM can provide the important data for design decisions to a product's function based part count reduction that can enhance the design and improve costs.

**References**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