2024 DFMA® Forum June 18-19
BOOTHROYD DEWHURST, INC.

With DFMA®…the Song Remains the Same

Matthew Miles
Senior Manufacturing Engineer

Returning after the Pandemic

The changes that have occurred in the world over the past few years have impacted almost everything within businesses and everyone's day-to-day life. Businesses had to adjust to contend with an extraordinary global pandemic. Workers adjusted also, and in many ways, appreciated working remotely, as it allowed more flexibility to addressing personal itineraries, while still performing work duties. However, in some cases, others were not as fortunate. Some experienced job losses, retired early, switched careers, and overall reassessed their current work/life balance.

Personally, through the pandemic, I was fortunate in that I only had to make the adjustments to working remotely and then adhering to the COVID protocols while returning on-site as I continued working and practicing DFMA® (Design for Manufacture and Assembly). I did experience some changes though. New opportunities arose with other companies to work on different products, but I was not averse to pausing and taking stock in the work/life balance as well. What I found, and surprisingly realized, was just how long I have been practicing DFMA® and applying it to product development. I noticed that throughout the years, no matter the company, no matter the product, the steps to practicing DFMA® remain the same.

As the DFMA® community returns to the yearly forum, this year's paper will discuss that while each company may have different product types, different people, different cultures, and different strategies, many of the same reliable approaches exist when applying and sustaining DFMA® within a company. These similarities will be reviewed, but also what changes can be made and addressed from a different perspective on DFMA® implementation. Steps that to Unmanned Systems is taking to achieve positive results with DFMA®.

Work-Life Balance

The closest I ever came to really thinking about a pandemic came in the form of a risk factor input used in a Total Cost of Ownership (TCO) analysis. But, did that ever change in March 2020. The COVID pandemic upended the business world. We first had to get used to working entirely remotely. In most cases, engineers were able to continue to perform their duties in the remote setting. Then, a return to the office and the shop floors slowly occurred with many safety protocols to follow. There were severe disruptions to supply chains worldwide. In other industries outside of product development, people and businesses were severely impacted. Many people thought of changing companies, retiring early, or changing careers altogether. The other area the pandemic impacted was towards people's day-to-day itineraries. As commutes were eliminated for the time being and schedules were more flexible, people took advantage of the ability to run errands while flexing their work hours.

I am aware that this is just scratching the surface of discussion points regarding the pandemic, but wanted to include the portion that made a lot of people think about their work-life balance. Coming back to some normalcy from the pandemic, people reassessed things and in a lot of cases made those career or company changes. Permanent remote and hybrid work schedules were also made available in the following years. Employers also had to emphasize their approach to employee engagement and retention. Some employers used Gallup's Q12 Employee Engagement Survey to assess employee engagement.

On a personal level, I had changes occur, but was still able to continue applying DFMA® toward product development. At the end of the pandemic, I started to reflect on the DFMA® software and philosophy. I found that even though I have applied DFMA® techniques to different products, if the same steps are put into place, success will follow. The next section will cover those steps and what the benefits are to the companies and individuals that use DFMA®.

DFMA® Defined

Boothroyd Dewhurst's (BDI) DFMA® software is used for product simplification and cost improvement by many companies. The two-part software of Design for Assembly (DFA) and Design for Manufacture (DFM) helps product engineers optimize their designs for ease of assembly and total cost. DFA focuses on part count reduction by using proven minimum part criteria questions and DFM helps the engineer select the most cost-effective materials and processes to use for manufacturing the parts. DFA estimates the labor time required to assemble the product based on a series of part handling and insertion difficulty questions in order to minimize this time as well. The overall goal with DFMA® is to minimize the total number of parts, improve ease of assembly, and also minimize product cost. This is done by using DFA to reduce the number of parts in the assembly and then understand and minimize the cost of the individual parts with DFM.

The simplest way to define DFMA® is that it is a design tool within the engineer's toolbox. Applied early in the design process it is a powerful engineering tool. It benefits companies by reducing labor costs and the number of parts in product assemblies, along with peripheral reductions. Such as reductions to weight, tooling costs, and assembly operations. These results have been compiled from many published case studies by BDI.

As a practitioner of DFMA®, the individual can gain benefits through learning the software as well. I have found that using the software is helpful in creating a process of continuous learning for the user. Learning the DFMA® software can help expand one's knowledge base in the design of product assemblies, but also ties into areas such as supply chain and suppliers, materials, processes, lean manufacturing, and the quality side of products. Extracting the data from DFA and DFM analyses also requires learning how to properly communicate the data to co-workers to get the proper message out that factor into design decisions.

Summarizing DFMA® work in a forum paper can also enhance one's ability to present a design case study and expand on one's technical writing ability. Forum papers from others are great ways to learn more about the DFMA® tool by reviewing the steps they

have taken. Comparing and learning from other forum presenter's papers can help enhance one's overall DFMA® knowledge. Enough time spent at running DFA and DFM analyses while performing the supporting work and communicating what was done will develop your skills enough to be considered a Subject Matter Expert (SME) in DFMA®.

While I am describing some of the steps that I have taken, I should point out that the most important part of the DFMA® journey is working and sharing knowledge directly with others. Some of the strongest learning comes from participation in or facilitating cross-functional DFMA® workshops. These are usually multi-day workshops where members from all engineering disciplines and other group representatives from manufacturing, supply chain, project management, and management in general, collaborate. Becoming an SME and facilitating workshops leads to mentoring others during these sessions. As I look back on my years in DFMA®, mentoring others on the software and philosophy is the most satisfying aspect as an SME. To see others gather and apply the techniques, grasp the concepts and understand the DFMA® process provides the greatest sense of accomplishment as a facilitator. It also means that they will be seeing successful results on their products through DFMA® use.

Opportunities from DFMA® come in a couple of different forms. For one, learning this powerful engineering tool can help one professionally. There will always be a place for an engineer that has the ability to cost reduce products. Running the actual DFA and DFM analyses present the opportunities to improve the product. Analyzing is still like solving a puzzle to me, whether it is in DFA or DFM. A completed DFA analysis will show what opportunities exist for part count reduction. Brainstorming and applying one's design creativity follows during the ideation aspect of a project. On the DFM side, even in the middle of a DFM should-cost analysis, I am projecting what the final cost estimate is going to be and how it might compare to the supplier's costs.

After defining the DFMA® software and how it benefits companies and individuals, the next section will review my journey with it and some of the experiences I have gone through.

Using DFMA Through the Years

I started using the DFMA® software in 2006. That began with applying it to a trial project at the company I was with at the time. They were assessing whether to invest in the software. After completing that trial project successfully, the company did purchase the software and then the focus turned to how to implement the DFMA® methodology into the companies everyday set of engineering tools.

Since then, opportunities in different roles presented themselves as I honed my skills in DFMA® use. Such as working in Value Engineering, Advanced Manufacturing, and as a Continuous Improvement Leader, for example. Last year, in 2023, I was working with a younger engineer who was fresh out of college. As we discussed DFMA®, he asked how long I have been using the tool. The part that got me as I answered him, wasn't the number of years in DFMA®, but just how those years seemed to have snuck up me. I did not realize that I had been practicing DFMA® for seventeen years, and now eighteen.

During these years I have applied DFMA® to numerous product types, at different companies, and with different co-workers, but the results were consistently positive. Some of the products I have applied DFMA® to are shown in Figure 1.

Product Types with DFMA® Application	Assembly Part Count	Attributes	Operating Temperature
Electric Material Handling Equipment	+3000	Lead acid battery, 24/48V DC	-30° to 43° C
Sensing/Test Instruments for Plastics	+2000	Touchscreen user interface, 120/240V AC	425° C
Industrial Printers	+2000	Touchscreen user interface, 90/240V AC	125° C
Batteries for Grid Energy Storage	+5000	Liquid-metal battery	+500° C
Unmanned Underwater Vehicles	+2000	Lithium-ion battery	-2° to 30° C

Figure 1 – Industrial Product types

Coming back from the pandemic, changing companies, mentoring younger engineers, and realizing how long I have been practicing DFMA®, made me do some self-reflection after it was announced that BDI was hosting another forum. Having presented at previous forums on a range of how-to topics, such as how to implement DFMA®, or the details of running DFA/DFM analyses, led me to reflect on how consistent DFMA® is no matter the product, company, or people.

Over these eighteen years, things do change, such as what you do with your time. Activities and new hobbies may come about. Once such hobby for me has been a lifelong desire to learn to play the drums. As it was time to return to the forum and choose a forum paper topic, DFMA®'s consistency as an engineering tool reminded me of a song from the 70s, "The Song Remains the Same." The background on the song was that as the group who wrote it toured the world extensively in the early 70's, they experienced many different cultures and people while doing so, but they noticed, in their words, the song remained the same to the audience. Meaning, people reacted to the music the same, as if it was a universal or global language. People of all languages and cultures could communicate as one with the music. Through my experience with DFMA®, I have seen companies, products, people and the cultures inside those buildings that are all different, but DFMA® is the same, a universal language to engineers in product development.

With analogy in place, the next section will display the steps Unmanned Systems has taken in their DFMA® deployment and what makes it a universal engineering tool.

Unmanned Systems

Unmanned Systems (UxS) is a part of one of the three divisions within Huntington Ingalls Industries (HII). HII is the largest military shipbuilding company in the United States. They consist of three divisions, Ingalls shipbuilding in Mississippi, Newport News shipbuilding in Virginia, and Mission Technologies (MT) companies. Unmanned Systems is a portion of the Mission Technologies division and is located in Pocasset, MA.

UxS designs and produces unmanned underwater vehicles (UUVs) for defense, marine research and commercial applications (see figure 2). The UUV models are referred to by their abbreviated name, REMUS, which stands for Remote Environmental Monitoring Units. The four different vehicles produced have a model number that equates to the ocean depth the vehicles can reach. The R100M, for example, is 100-meter depth rated. UxS makes small and large class UUVs. The vehicles range from 10 to 60+ hour mission durations. The small class UUVs are two-person portable. The designs consist of an advanced modularity and open architecture with a variety of configurations for the customer and field-swappable energy modules.

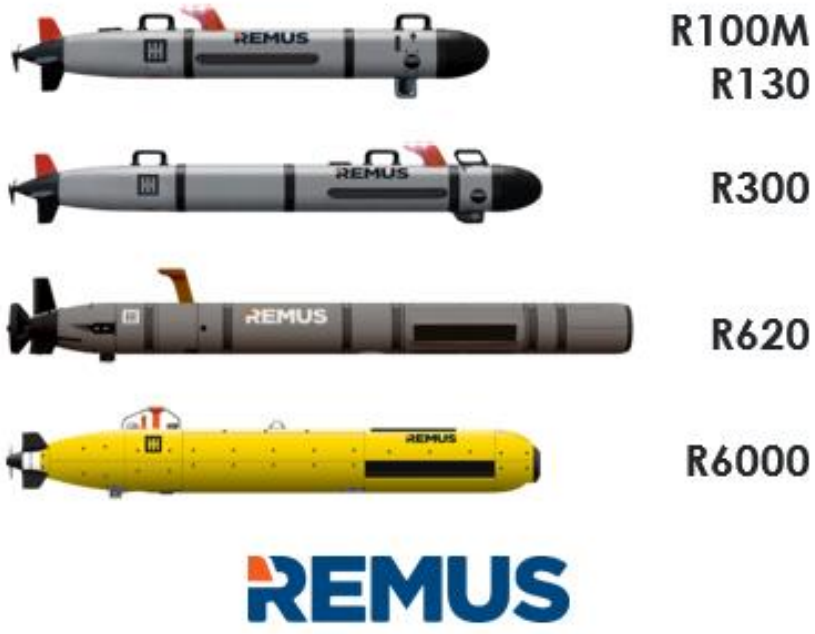

Figure 2 – Unmanned Systems UUVs

UxS UUVs have a variety of acoustic communications and antennas. Other features include side scan sonar, doppler velocity log, and a 1TB removeable solid state hard drive. The VIP (Vehicle Interface Program) Software is used for missioning programming and post-mission analysis. Camaras and other auxiliary equipment are also available. The UUV applications include; Mine Counter Measures (MCM), Intelligence, Surveillance, and Reconnaissance, Search and Recovery Operations (SAR), Hydrographic Survey, and Rapid Environmental Assessments.

What is the Same

UxS has taken a lot of familiar steps to implement their DFMA® program that started in 2019. Establishing a DFx program was one of three key company initiatives that year. And UxS chose to purchase the DFMA® software in 2019 after attending BDI's forum. During that time, UxS representatives performed some data gathering with SME's on DFMA® from other companies to develop their implementation plan. A charter was developed for the DFMA® program. UxS then looked at how to integrate DFMA® steps into their product development process. An initial training workshop with BDI on the software use was the next step.

UxS started by gaining executive support to launch the initiative and then developing a DFMA® support structure for the deployment. Following the initial setup, they began applying DFMA® to trial projects to kick off the application of the tool. 2021 saw another visit by BDI to complete more DFMA® application and also included Implementation Training. This included how to set up roles and responsibilities within UxS, developing a user's guide process sheet, and a process workflow for DFMA®. Also established was setting up a data and files repository for all DFMA® analyses. UxS followed a lot of the same steps most companies follow when they embarked on their DFMA® journey.

UxS chose to have the manufacturing department be their DFMA® drivers. The manufacturing engineers would conduct the DFA and DFM analyses within the development projects. Multi-day workshops would be held to review the DFMA® data with cross-functional project teams. When it comes to the tactical work on the DFA and DFM analyses, again, UxS followed the same steps relayed to them from their data gathering from other companies' SMEs.

A DFA analysis is the starting point on the selected module or sub-assembly in the UUV design. Manufacturing runs the DFA analysis and summarizes the data, such as DFA Index, part count, labor times, and identifying opportunities for part consolidation or design simplification. One step that UxS included was bringing in the module assembler into the DFA process. The assembler's feedback is collected to bring up any assembly

difficulties and relay that back to engineering. The manufactured parts within each module were then identified to run DFM should-cost analyses. This is commonly done with the DFM portion of the software to estimate part manufacturing costs and compare to the supplier costs. This way any potential cost savings can be identified and reviewed with the supply chain buyers and suppliers in negotiations on part costs. Once the completed DFA and DFM analyses are completed, the cross-functional team review takes place. During this review the team identifies any opportunities for design and cost improvements to investigate.

By reaching out to experienced DFMA® SMEs, UxS has established the same type of DFMA® program that leads to success in product simplification. Being in manufacturing and having manufacturing drive the DFMA® program is a first for me personally. But, there some advantages to having DFMA® established in this department. From this perspective, the DFMA® data is being tied to other analyses such as design and process failure modes and effects analysis (D/PFMEAs), production readiness reviews (PRR), manufacturing readiness level (MRL), and the technical data package (TDP) transfer from engineering-to-manufacturing during product iterations and launches. Additionally, DFMA® data aides manufacturing in developing work instructions, process routings, and continuous improvement efforts.

UxS has followed proven steps for establishing their DFMA® program. The program does need to be sustained though. Steps we are looking to take to grow even further with DFMA® include conducting even more multi-day, cross-functional workshops, continued training, and establishing a DFM should-cost program for supply chain. The DFA efforts are slightly ahead of the DFM program at UxS. However, steps to further the should-cost program have already been taken and it is gaining in momentum. All the DFMA® building blocks are in place and UxS just has to continue to stay the course with their program.

Having worked in various departments driving DFMA® and now working in a new department, the next section will look at advantages and disadvantages to DFMA® driver locations in the organizational structure.

DFMA® in the Organizational Structure

In addition to working on various types of products, a DFMA® SME may also find themselves working in different departments within the company structure. That will depend on the approach the company takes to set up the initiative. Who are the SME's and which department or position will drive DFMA®? That will also vary depending on the company and product. Management will need to decide what they believe will work best for them. I have had the opportunity to work in department's all across the product development value stream during my years practicing DFMA®. From that experience, the following are my recommended locations in the organizational structure for positioning the DFMA® driver (see Figure 3). They are ranked in order of biggest impact to product development, along with the pluses and minuses of each location:

1. **Engineering** – It could be way up front in the Research and Development area of engineering, if the company has that group, or in general product development, but making engineering the driving force behind DFMA® is the most logical place and can have the most desirable results in terms of product and cost optimization. This is because DFMA® is best applied as early as possible in the product development process. In the concept phase, design changes via part reduction are easier to perform than later in the process when the design has already been through iterations or even locked-in.

The largest hurdle of having engineering driving DFMA® is it takes longer to find acceptance. Common excuses from engineering are that DFMA® is another tool that they do not have time for and they have already been designing products without it, so they do not need it. Time to market for products factors into this. From my experience, time-to-market has become the end-all, be-all in modern product development. I have heard management state, "just launch the product, and we'll cost reduce later," many times. This approach can get the products out the door quickly, but opportunities for product optimization will be left on the table.

2. **Advanced Manufacturing Engineering (AME)** – AME groups or an individual AME role would be the next best place to position the DFMA® drivers. This type of role usual represents the manufacturing team, but is positioned more closely to the engineering group. An AME member included in the product development team will typically have an earlier look at the product design and can provide DFMA® support just as if the drivers were in engineering. However, an AME does not design nor own the design. The AME can make DFMA® recommendations enduringly, but those recommendations may be disregarded by engineering departments for the same acceptance reasons previously mentioned.

3. **Value Analysis/Value Engineering (VAVE)** – VAVE groups are common departments set up in product development companies whose sole purpose is to work on product cost reductions. This stems from Value Engineering's (VE) birth during the World War II time period. As resources were being used up in the war effort and shortages occurred, the VE methodology was created by Lawrence D. Miles (no relation) to find alternative materials and processes to use in products to continue aiding the war effort. At first, VE was adopted vastly at the Department of Defense (DoD) and then made its way to public companies to specialize in cost reduction. While the VE methodology focuses on function analysis of systems, its approach is very similar to DFMA® and is why the two tools can work hand-in-hand within a Design for Value (DFV) approach to product development.

The challenge with VAVE groups driving DFMA® is that they are thought of as just that, a cost reduction group. That stigma is also tough to overcome, combined with the fact that, just like AME, VAVE groups do not own the design either. If they are set up to reduce cost, they will have to apply cost reduction techniques post-launch of the product, where the design is locked-in and the cost savings will be far less than the cost-avoidance opportunities VE/ DFMA® could provide at the concept phase.

4. **Manufacturing Engineering** – The main advantage of having manufacturing be the DFMA® driver is that they are the group that assembles the product and would find more intimate details other groups may not be able to see. Tapping into the

assembler's knowledge of any assembly pain points during a product build can be invaluable to design teams. However, this feedback is best captured during concept or prototype builds. And that is the issue with having DFMA® led by manufacturing, if not properly represented early in design project discussions with engineering, being too far away from engineering could be detrimental to the development process.

5. **Continuous Improvement (CI)** – I have previously worked in a CI group where the DFMA® and Lean Manufacturing initiatives were paired together. These are also two tools that logically work well together. However, being a group on the outside of design, like AME or VAVE, limits the impact. CI's stigma is that it is common to solely think of CI groups as being associated with Lean Manufacturing only. The DFMA® initiative just may not carry the same weight as having it driven from the other groups mentioned.

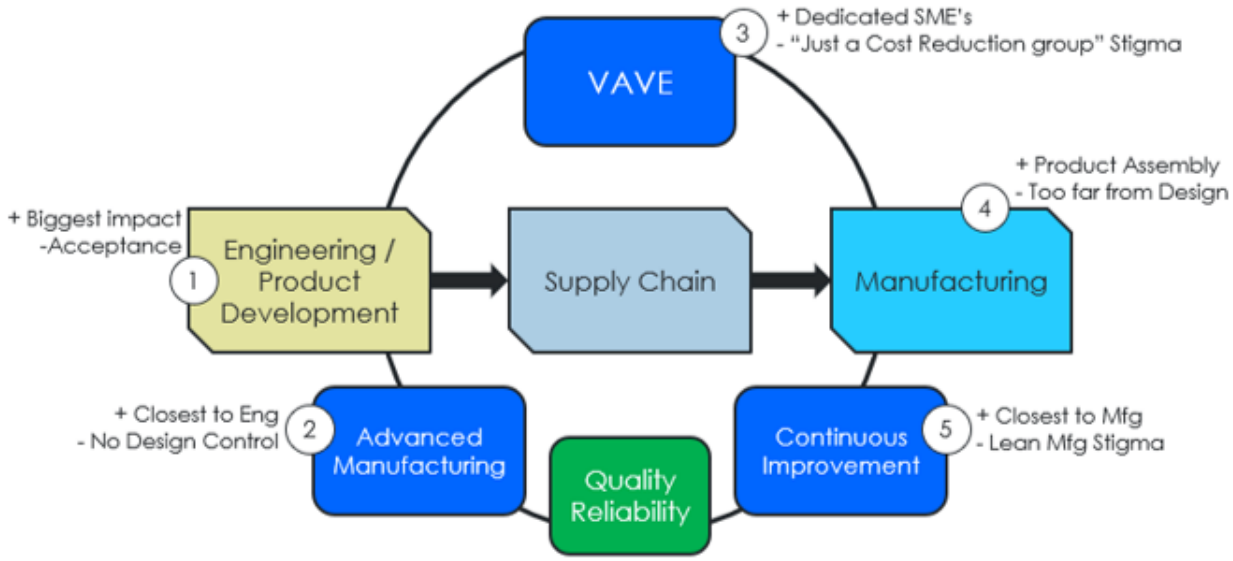

Figure 3 – DFMA® in the Organizational Structure

As I have reflected upon the years practicing DFMA®, I have also noted the different positions have advantages and disadvantages for each. And, that it may be beneficial to relay these experiences at the forum for companies just starting out with DFMA®. Again, Unmanned Systems has chosen to have manufacturing engineering as the

DFMA® drivers. While this approach is new for me and even though it was given a fourth-place ranking position, we are still seeing a positive impact within the company. There is interest, engagement, and support from our engineering and project management groups as we apply DFMA® to our products. Any department where DFMA® is positioned will have a positive impact to product development, but as noted, engineering is the ideal group to lead the charge.

The key to this is establishing the support structure for the initiative. Buy-in from top management, a plan for the DFMA® SME(s), process definition, and integrating the tool into everyday product development work all have to be factored into the plan. I have worked in all of the departments shown in Figure 1, including the supply chain department not previously discussed. There are advantages and disadvantages to each, but a steady and persistent approach with DFMA® will yield positive results.

Summary

Years ago, a co-worker forwarded to me an article out of a SAVE (Society of American Value Engineers) Journal. The article described a company's approach to implementing and adopting the value engineering (VE) methodology within the company. As previously noted, VE and DFMA® are similar engineering tools and work together seamlessly. Both can aide in improving products and reduce costs. With those similarities in mind, what jumped off the page in the article's summary was how they structured the initiative and the phrases they used to describe the experience.

The first section defined how the company was successful in selling the VE initiative to top management. Their next step would be to sell to the next level of management and get their buy-in. From there, they had to determine how they would structure the VE department within the organization. They concluded that their new VE group should be a staff function as it must work through all departments and cross-functional lines. In describing their VE group's early efforts, they stated, "our Value Engineering Section is in its infancy. Potential cost savings have been indicated through its efforts. These potential savings cannot be realized until the ideas have been implemented."

Paraphrasing, the identified product improvement and/or cost savings cannot be realized by the company until the changes have been released into production. And lastly, while their VE group will continue to apply the VE methodology towards their products, they will be tasked with training other departments in the VE techniques and philosophy.

Selling management the initiative, structuring it within the company, cross-functional teamwork, identifying/realizing savings, and training on the techniques and philosophy…for the last eighteen years I have heard, used, and lived these words while deploying DFMA® at different companies. A DFMA® program can easily be swapped with the VE initiative from the story as all of the steps they took with the VE group are also relevant steps for a successful DFMA® implementation. With DFMA®, the song does remain the same, as that article from the SAVE Journal was published in…1962.

The implementation steps and the application of DFMA® have stood the test of time. Implementing the initiative can be done regardless of the type of product and industry it serves. Once the fundamental support structure is in place, the DFA and DFM tools and philosophy, can be applied. To me, the two most important phrases used in the VE article were "cross-functional lines" and "techniques and philosophy." I have mentioned that cross-functional work is key in a DFMA® program many times already. It also takes creating a mindset to implement an initiative like DFMA® within the cultural walls at a company and it IS a philosophy in addition to being an engineer's design tool. Furthermore, over six-hundred papers have been written and presented at BDI's DFMA® forums through the years from different companies, products, people, and business cultures, with the same positive results. DFMA® is a powerful, universal tool for a company to deploy and a powerful tool to master for the individual's knowledge base and skill set while working in product development. And, it is never too late to start the journey.