Six Lessons Learned from a Successful Design For Assembly Program
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Each company works with Design for Assembly (DFA) methods for different reasons. Some companies want to take cost out of their products, some want to make more products in their factories, and some want to simplify the product to increase quality and reliability. In a growing market a company wants to reduce labor content to get more products through the factory to meet demand without adding assembly workers. And, in a growing market a company wants to reduce the floor space required to meet demand without building another factory. Remarkably, the goals are similar for companies in declining markets, though the reasons are different. In declining markets, companies want to meet demand with the fewest assembly workers so that work from consolidated plants can be brought into the factory without adding assembly workers. And, the freed up floor space is desired to provide space for the work from the consolidated plants. In either case, a successful DFA program can help.

Done well, a DFA project can result in material and labor savings of 50%. But, it takes more effort to put in place a sustainable DFA program that becomes part of a company's culture. Six lessons learned are described from a successful DFA program at Hypertherm, Inc., a privately-held company that designs and manufactures plasma cutting systems for the metal cutting industry.

1. The first DFA effort is leap of faith.

No matter how you slice it, the first DFA project is a leap of faith. Without guarantees and without certainty of results, someone in the organization must muster enough courage, or realize enough fear, to start DFA. The most positive way for the leap of faith to come about is in response to a well-intentioned BHAG (big, hairy, audacious goal)[1] issued from a company leader: "I want you to take 50% of the cost out of the next product". Congratulations. You now have the reason to try DFA. You simply call a meeting of the design leaders and tell them what you were asked to do – take out 50% of the cost on the next product. After their chuckles subside, ask them if they know how **they are** going to meet the BHAG. When they say no, you bring up the radical idea of DFA. The design leaders will think you are nuts because no one in their right mind can take 50% of the cost out of the product, especially with those simple-minded DFA tools. So, give them a couple days to think of an alternate approach then call another meeting. If no one has a better idea (and they won't), you get to try the DFA tools. The BHAG scenario is the preferred scenario because less start up momentum is required since all the team is doing is responding to an important company leader's BHAG. No one wants to get in the way of that BHAG.

The non-preferred scenario is called the "DFA or bust" scenario. If the company will go out of business if costs are not reduced by 50%, then give DFA a try. What can you lose? Pressure will be immense since everyone's job is relying on DFA, so you'll surely have everyone pulling the boat in the same direction – DFA or bust.

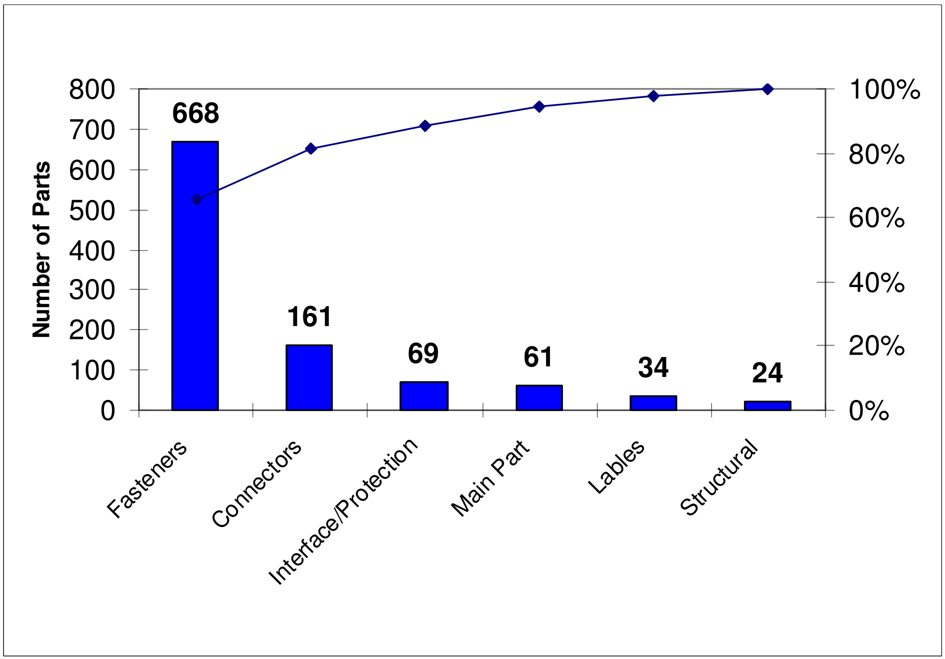
2. Before DFA training, the engineering team must build the baseline product and create Pareto chart of part count by part type.

Design engineers believe that the last product we designed is infinitely good, just ask us. We believe that the product functions well and is easy to assemble. Customers know that the product doesn't function perfectly (that's a discussion for another time) and manufacturing knows that the product is difficult to assemble. However, design engineers rationalize the assembly weaknesses by saying “Manufacturing builds them every day, so it must be easy”. For a successful DFA program the design engineers must be convinced that there is room for improvement. No amount of discussion or argument can convince the design engineers that their product is difficult to assemble. It takes first hand experience to convince the design engineers that their design is sub-standard from an assembly standpoint.

First hand experience is obtained only on the production floor. Send the design engineers out to the floor to build the baseline product under production conditions. Production tooling and production documentation are used and production build times must be adhered to. When the design engineers come back to their desks tired and bloodied after their experience building the baseline product, the convincing is almost complete. The design engineers have new-found respect for the assembly workers and new-found disrespect for the baseline product. It’s now time to complete the convincing phase by exploiting their “data-driven approach to life” and asking them to create a simple chart called the Pareto chart of part count by part type.

The first step in creating the Pareto chart is to have the design engineers create part types for the parts, e.g., fasteners, connectors, interface/protection, main parts, labels, and the like. Then the design team assembles the baseline product (again), counts each part and assigns the parts to a type. This process is painstaking and worth the expense. Figure 1 shows an example of a Pareto chart of part count by part type.

Once the Pareto chart is complete the design team starts trying to figure out how on earth so many parts were stuffed into the product while they weren’t looking. They now have a signature and an objective measure of the baseline design, and the plan of attack is clear. For example Figure 1 shows that about 80% of the parts are either fasteners or connectors, so the plan of attack is to reduce these parts first. Though this is always the first place to attack, the design, engineers have their data and they know how to proceed. The design team is now ready for DFA training.



<u>Figure 1. Pareto chart of part count by part type for the baseline product’s main power supply in a plasma cutting system.</u>

3. Set an explicit goal of 50% part count reduction to focus and drive the DFA effort.

A simple goal goes a long way toward focusing the DFA efforts. Without a doubt, a part count reduction goal is the best place to start. There are two reasons to focus on part count reduction. First, part count reduction is the mechanism for eliminating labor content. There is no design tool that takes labor content out of a product. Instead, reduced labor content is the **result** of something – part count reduction. DFA takes parts out of the product and reduced labor content follows. Second, part count reduction is easy to measure and people can understand it. To start, no other goals are required.

The DFA leader must now walk the walk. So, with a stiff upper lip and a straight face, the leader must actively promote the mantra: "Take out 50% of the parts". In fact, since you know the number of parts in the baseline product, you can translate the 50% reduction mantra into an explicit number of parts. In my case the first baseline product had about 1000 parts and everyone on the design team knew how many parts the new design was going to have – 500. So, at every opportunity, at every turn, at every meeting, in the cafeteria, while on a lunchtime run, I told the designers how many parts the new product would have.

You must keep in mind that the design team still thinks you're out of your mind because no one can take 50% of the parts out of the product. The best way to get past this phase is to acknowledge that you're out of your mind, and then train them in DFA. At the first flare-up of discontent you can always ask the disgruntled engineers if they have a better idea. That usually shuts them up until the training is complete.

4. Part count reduction is a surrogate for reduction in non-value added (NVA) activities

Non-value added (NVA) activities, or activities that the customer will not pay for, or waste, are best understood by the Lean thinkers who lead the daily crusade against NVA activities. Lean thinkers have the mindset and the toolbox to eliminate NVA activities throughout the organization. The NVA activities were first grouped into seven wastes by Ohno[2] (see Table 1) and elegantly described in cartoon format by Suzaki[3] (see Figure 2). The Lean thinkers have largely been relegated to NVA reduction on the manufacturing floor where Value Stream Mapping (VSM) is the tool of choice to define the activities, resources, and information flow required to deliver value to the customer.[4] What's different about the Value Stream Map is that a time is put to every activity in the value stream and each time is defined as value added (VA) or non-value added (NVA). It's common for NVA time to make up more than 95% the time in the value stream. Since NVA time makes up most of the time in the value stream, huge time savings are realized even with modest percentage reductions in NVA time.

Table 1. Seven Wastes, from Ohno

1. Waste of overproduction *(of parts)*
2. Waste of time on hand - waiting *(for parts)*
3. Waste in transportation *(of parts)*
4. Waste of processing itself *(parts)*
5. Waste of stock on hand – inventory *(of parts)*
6. Waste of movement *(from parts)*
7. Waste of making defective products *(using parts)*

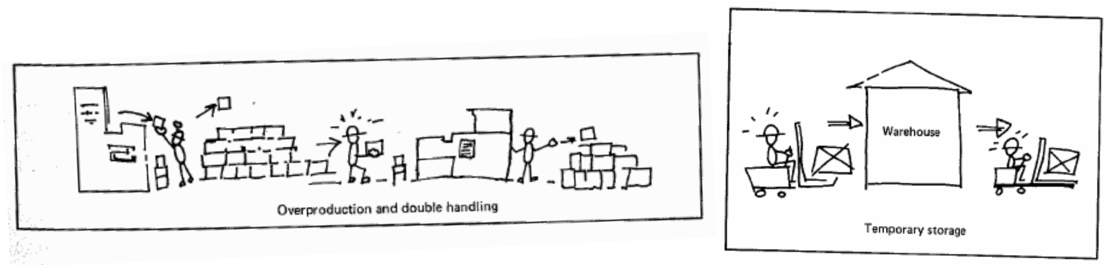


Figure 2. Cartoon of two wastes, from Suzaki.

The Lean toolbox does not simply erase NVA time from the value stream; reduction in NVA time is the **result** of something – a reduction in the NVA activities themselves. And, since the NVA activities (described by the seven wastes) are strongly linked to part count, reduction in NVA activities **results** from reduction in part count (among other things). This causal chain is shown graphically in Figure 3.

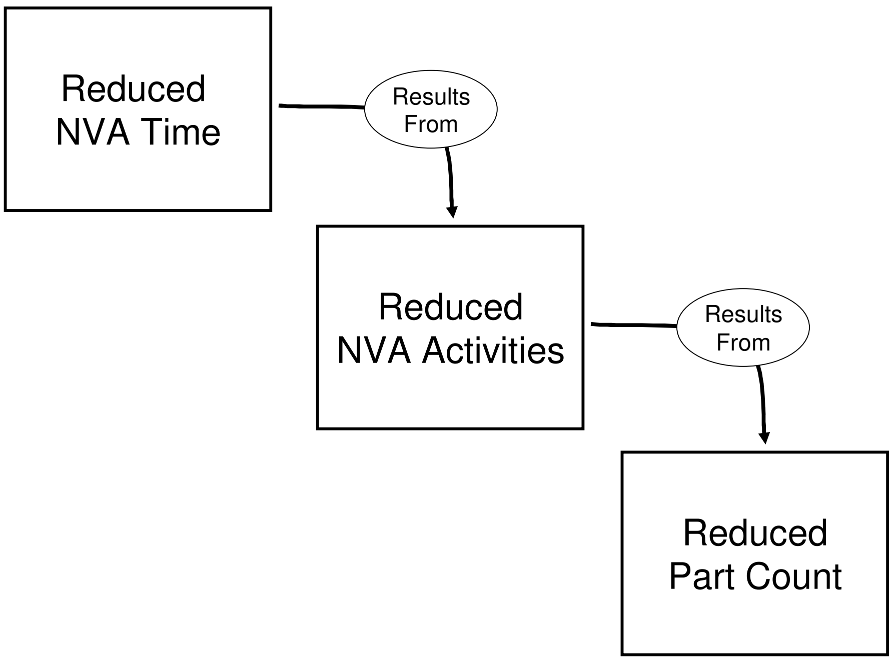


Figure 3. Causal chain of NVA time, NVA activities and part count.

Historically the design teams have been isolated from the Lean initiatives, and part count reduction efforts have not been part of the Lean equation. But, even without the design teams, the manufacturing floor has generated significant savings. It is amazing, however, to imagine the savings if the design teams were to become involved. Their involvement would result in fewer parts to over produce (e.g., make the wrong ones), fewer opportunities to wait for late parts, fewer parts to ship, fewer to receive, fewer to move, fewer to store, fewer to handle and fewer opportunities for incorrect assembly. If you open up your mind, the list broadens: fewer suppliers, fewer supplier qualifications, fewer late payments, fewer supplier quality issues, fewer expensive Black Belt projects. Most important, however, may be the reduction in transactions associated with reduced part count, e.g., work in process tracking, labor reporting, material cost tracking, inventory control and valuation, BOMs, backflushing, routings, work orders and engineering changes.[5] So, focus on part count reduction.

To close this line of thinking I want to mis-quote a good friend: “As a design engineer, I can design more waste into a value stream in one afternoon than a sea of Lean thinkers can take out in a lifetime”.

5. Measure floor space productivity.

Figure 4 shows a breakdown of product cost which is the average of multiple hundreds of products.[6] Though the breakdown is not correct for any one product, it is good estimate for illustrative purposes due to the large sample size. It’s clear from the graph that the labor component is small. Therefore, the relative savings from labor reduction is small (though that won’t stop most from fixating on labor savings). The next largest slice is overhead. Each company calculates overhead costs differently, and the calculations are usually artifacts of traditional

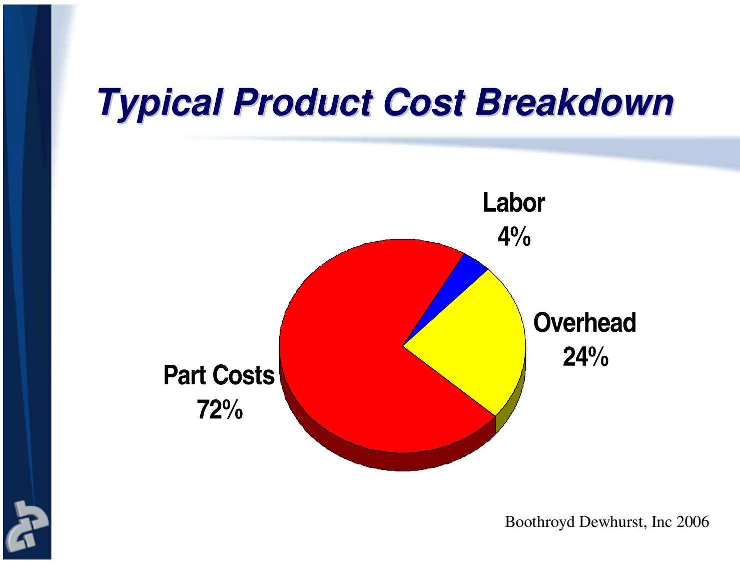


Figure 4. Cost breakdown from multiple hundreds of products [6].

cost accounting practices and have limited physical interpretation. Frankly, the calculations confuse the hell out of me. Overhead cost is a business metric that is far removed from the actual activities occurring on the production floor. What is needed is a straight forward process metric that is easy to understand. Floor Space Productivity (FSP) is a good one. FSP is defined here as the profit dollars shipped per unit time divided by the floor space required to achieve the profit (shown in equation 1). If the time interval is one day, the units of FSP are dollars per day per square foot.

Floor Space Productivity (FSP) = profit per unit time / required floor space (eq. 1)

FSP is a simple metric that has a clear interpretation — meaning everyone understands that increased profit is good and everyone understands how to measure floor space. Also, profits and floor space are usually well known or easily calculated. FSP is an effective metric for evaluating the effectiveness of a DFA initiative because it captures profitability and the required factory size in one metric. Done well, increasing FSP can avoid the purchase or construction of a new factory. We should measure our design teams against the FSP metric.

So, how much floor space is required for product A versus product B and how do you reduce the required floor space? A good rule of thumb is that the required floor space is proportional to the work content (value added activities) and waste (non-value added activities) associated with assembling the product. In equation form it's shown as

Floor Space $\propto$ VA activities + NVA activities. (eq. 2)

Here's an example calculation to justify, or at least explain, the rule of thumb. Takt time, or the time needed to produce a product in order to meet demand (D) is

takt time = number of available hours / D. (eq. 3)

Assume the demand (D) is 6 units per day and there are 6 available work hours per day, with D = 6, number of hours = 6,

takt time = 6 hours / 6 units = 1 hour.

The number of assembly stations required to meet demand is defined by equation 4.

Number of Assembly stations = (VA time + NVA time) / takt time. (eg. 4)

Assume VA + NVA times = 10 hours, takt time = 1 hour, equation 4 becomes

Number of Assembly stations = 10 hours / 1 hour = 10.

Now assume that each of the 10 assembly station requires 100 square feet.

Floor Space = Number of Assembly Stations X Floor Space per assembly station (eq. 5)

Where the number of stations = 10, floor space per station = 100 square feet, gives

Floor Space = 10 X 100 square feet = 1000 square feet.

Now, to demonstrate the rule of thumb that floor space is proportional to VA+NVA time, calculate that whole mess for a product with the same demand but with 5 hours of VA + NVA time (50% reduction). Takt time is still one hour because it's only a function of demand. But equation 4 becomes:

Number of Assembly Stations = 5 hours / 1 hour = 5.

Using the result in equation 5,

Floor Space = 5 X 100 square feet = 500 square feet.

Like before, floor space reduction is at the front of a causal chain where a reduction of floor space **results** from a reduction of work content (VA activities) and waste (NVA activities) associated with the assembly of the product, which in turn is the **result** of part count reduction. This causal chain is shown in Figure 5.

So, reduce part count to reduce VA and NVA activities and, ultimately, floor space.

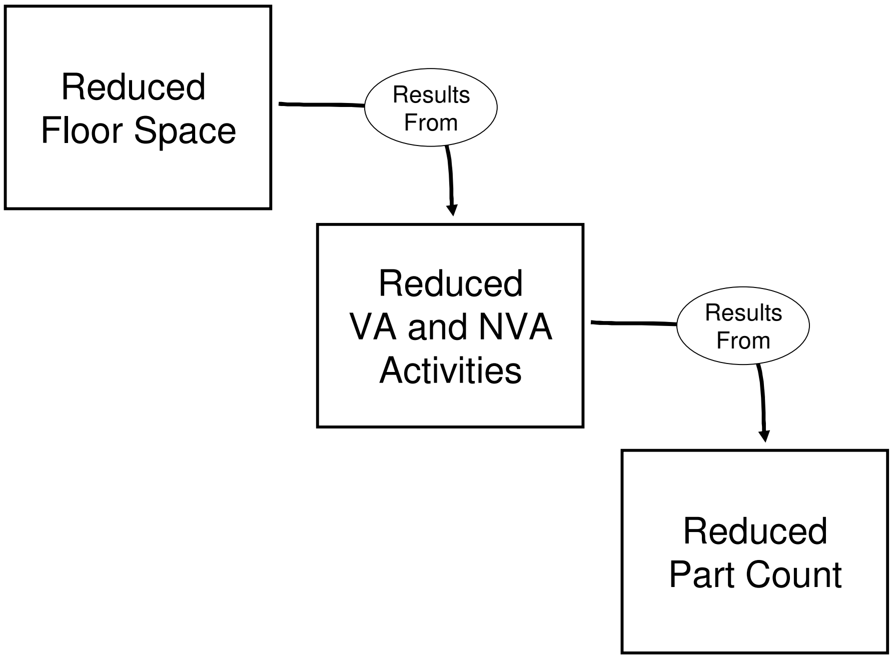


Figure 5. Causal chain of Floor Space, NVA time, NVA activities and part count.

6. Create simple before (A) and after (B) metrics for simple A/B charts sustain momentum

The key to sustaining momentum of a DFA program is a set of simple before and after charts that are presented to the Management Team after every project. The data for the “big bar, little bar” charts comes from evaluation of the baseline product and DFA analyses. The three important charts to maintain momentum (in order of importance) are as follows: product cost (labor, material, overhead), assembly time, and part count. Examples of each are show in Figures 6, 7, 8.

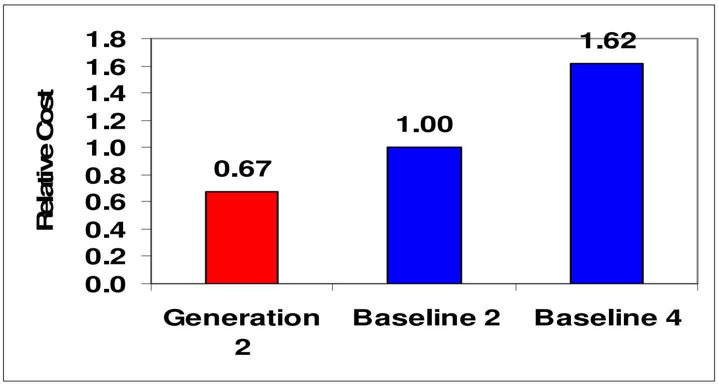


Figure 6. Simple A/B Chart for Product Cost .

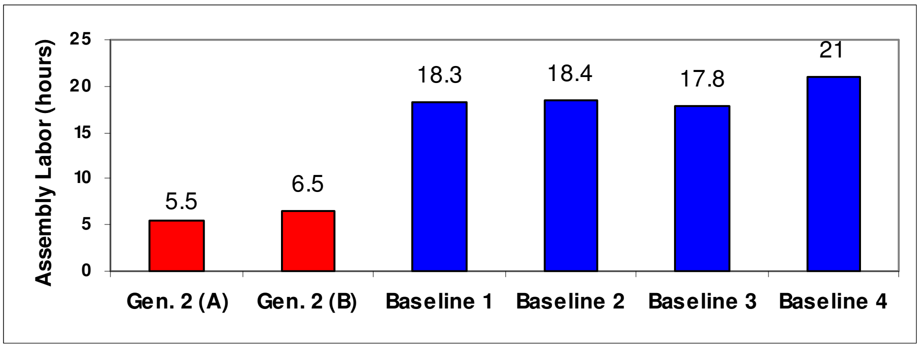


Figure 7. Simple A/B Chart for Assembly Labor Hours.

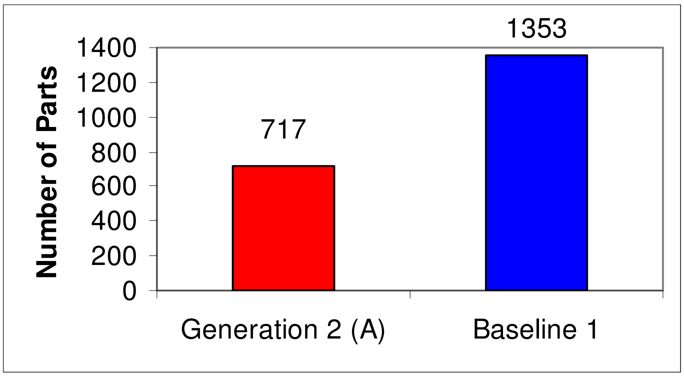


Figure 8. Simple A/B Chart for Part Count

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5. Maskell and Baggaley, Practical Lean Accounting, 2004.

6. Presentation by Nick Dewhurst at GE's Global Research Center, April 2006.