Chapter 12

Product Design

Why is product design important to operations management? What is product design? What about process design? "Don't most textbooks discuss these two topics as separate chapters?" Most textbooks do address these as separate issues and in separate chapters (although we are addressing these topics in separate chapters, the two activities should be conducted simultaneously or concurrently). The two topics are interrelated because they impact each other. The design of the product and the design of the process should be worked concurrently. The goal of this chapter is to show the importance of product design to overall operations management and to the process design/improvement activities.

Product design is tied to the strategy of the company as discussed in Chapter 3. A company's future products are not only strategic decisions but also have to be in sync with the strategy and focus of the company. Obviously, if the company is focused on reducing carbon footprints and producing sustainable, environmentally friendly products, the company will not want to produce ozone-depleting products. (We will discuss the idea of designing for the environment later in this chapter).

Product design or product development and the ability to continually produce new products to meet the needs of the customer may be the company's competitive advantage. For example, Rubbermaid has a goal of 300 new products developed each month. All these products will not see the shelves of stores, but the ability to continually produce new products produces a competitive advantage for Rubbermaid. 3M encourages employees to experiment on the clock to produce new products. The Post-it Notes was a result of one of these experiments. The employees were not trying to create the Post-it Notes but it did turn out to be a very profitable invention for 3M.

Goal of Product Design

Product design has a primary goal of producing a quality product that meets the needs of the customer. The product design operation is where the ideas for the product are generating; it is where the look of the product is conceived; it is where the components of the product are decided. This function of operations management is critical to the success or failure of the company. If a quality product is designed, tested, and produced in a production process that is well designed, and if the product meets the needs of the customers, the company will be successful. So, as you can see there is a direct link between product design and our earlier discussions of quality management. Obviously, this link ties to the internal costs of quality and relates to Crosby's ideas in "Quality is Free."

In order to design a product that meets the customers' needs, we need to know what the customer wants. The first step of the Motorola Six Sigma methodology is to define the customer, define what the customer wants and define how the company can do it better than the competition. So, how do we define what the customer wants? What if the customer needs a service and not a product? The design process is similar as we will see under the discussions of Design For Six Sigma.

Impacts on Product Design

Impacting the product design process is the fact that customers are demanding new products at an alarming rate and those products have decreasing product life expectancy and increasing technology with increasing complexity. I call this the "Apple Effect." Apple comes out with a new iPhone every year and everyone wants the new phone This leads to issues of inventory management, distribution, reverse logistics and end of life issues for products.

The availability to consumers of a wider variety of products through e-commerce also fuels the demand for new products. All of this means that the company must be more flexible than in the past. Remember that flexibility was discussed as a strategy for positioning the company to be competitive (hopefully as we continue to move through operations management, you will see that most of the topics are related).

The product design process should provide the company with the desired appearance of the new or improved product. The latest trend has been for "*new and improved*." There is no way that a product can be both new and improved. If the product is new there is no reason to improve it already. And if the product is improved, doesn't that imply that the product has been around and was deemed to need an improvement to keep it competitive in the marketplace?

The product design process should not only address how the product will look but how the product will be supported after the sale. A product design that does not consider this aspect may end up costing the company more over the life of the product than the company is planning for.

The product design must also consider the life cycle of the product. This includes not only the marketing, sales, and support of the product but also the forward and reverse logistics infrastructure to deliver and bring the product back if necessary.

Life Cycle

Another aspect of the product design is to plan from the beginning the end of life aspect of the product and what actions the company will eventually have to take to phase out the product and when support for the product should be stopped. Somewhere in the life cycle of the product, demand for the product will decline and may even stop. This must be considered as part of the product design process. The Giga Pet in Figure 12.1 is a good example of a short life cycle (The Giga Pet was the first virtual pet). The fidget spinners from a few years ago is another example of a short life cycle.

Figure 12.1: The Giga Pet

The Giga Pet became the “have to have” product in 1995. Every child had to have one. When we came back from Germany in July 1995 it was the toy of choice for every child—of my neighbor’s children had as many as ten on their belt loops. This was a great product for the summer. The Giga Pet had a puppy/kitten that had to be fed, watered, bathed, and played with on a regular basis. As the child played and fed the puppy or kitten, it grew to be a full-size dog/cat. The problem came when school started, and the dog was not fed and watered as regularly as during the summer.

When a Giga Pet was not fed and watered, like a real pet that was not fed and watered, the pet died. This could be traumatic for a young child, but with the press of a button, a new pet was created. A few days into the school year a note was sent home from the principals: “Giga Pets are not allowed in school and will be confiscated if brought in.” Initially, parents helped by playing with the pets but for those children with ten Giga Pets this became a chore. The result was that when the child came home from school the pets were dead. This was traumatic for the child. Of course, the Giga Pet could be restarted but when it died again, the thrill wore off. The result was the forecasters did not see the end of life of the Giga Pet and continued to produce the product. The Giga Pet went from the end caps and a price of $19.99 to the Dollar Tree and 99 Cents Only Stores. The same phenomenon was seen in 2018 with the spinners – everyone had to have one to play with but then some genius decided to make spinners with blades on them and quickly the spinners fad died.

Materials

The appearance of the product (how it will look) may dictate the materials needed for the product or may be impacted by the materials available to make the product. The product design process not only will determine how the product will look but how it looks may be determined by the performance specifications for the product and may be influenced by the dimensions or tolerances for the materials that will make up the product. Conversely, the materials needed to meet the desired tolerances may dictate the appearance of the product. How the product is supposed to be used may very well dictate the appearance of the product itself. Where the product being designed is going to be used may very well dictate the design of the appearance of the product.

Services

The design of a service is not that different from the design of a product. The same planning process is necessary to design a product or a service. Both design processes require the designer to understand what the customer wants in order to provide the customer with a product or service. What benefits should the customer get from the product or service? How will we determine that? A good service or product design will determine how to match the answers to these questions with a service or product that will meet the customers' needs or wants.

Making a Profit

The goal of the design process should be to not only design a service or product that meets the needs of the customers, but this product or service should be designed to be provided or produced as efficiently and cost effective as possible. Remember the primary reason for being in business is to make a profit. If a company cannot make a product efficiently and, in a cost, effective manner, the company cannot make a profit. The same is true of services; if the company cannot provide the service in a cost-effective manner the company will not be in business very long.

A quality design process will focus on getting the product to the market as quickly as possible. There is a difference between speed to market and haste to market. Speed to market is important. Speed to market means getting a quality product to the market as quickly as possible. Haste to market is getting a product to market quickly but not a quality product. Certain software companies are really good at getting products to market quickly, but they may not be quality products. This results in many revisions to the product to make it better. Apple did this with the iPhone 4G. To get the product to market quickly, Apple rushed the new iPhone to market knowing that there may be a problem with the reception. Seems in a haste to get this new product to market they knew that the reception was possibly flawed because of the placement of the antenna in the edge of the phone. If held in a particular way this antenna would be blocked thus preventing reception. The fix? Give each user a cover that will enable the reception no matter where the phone is held. This is haste to market. Almost every example of haste to market vice speed to market results in a reverse logistics operation and after sales service support. Speed to market vice haste to market results in few if any revisions to a product.

The Steps of Product Design

Most textbooks will lead you to believe that product design is a sequential and lock step process. However, for an effective product design the following steps must be conducted as close to concurrently as possible.

Traditional product design has all these steps working in a lock step sequence. Traditional design is much slower and more time consuming which can impact the availability of the product to the customer. Concurrent product design breaks down the barriers between departments (like one of Deming's 14 points) and works with cross-functional/project management teams to help speed the product to production and to the market. We will discuss this in greater detail later in this chapter.

- **Idea Generation –** Where do the ideas for products or services come from? What role does the voice of the customer play? Can you create your own market?
- **A Feasibility Study –** Can we make this product with the specifications that the customers want? Can we make a profit?
- **Prototyping and Testing –** Building the initial prototype of the product and testing (and maybe revising and retesting).
- **Finalize the Design and Plan for the Production Process –** Will the process be a make to order, make to stock, assemble to order, assemble to stock, or a project. Will the product be mass produced, mass customized, or produced one at a time?

Let's look at each of these parts of the product design individually. Although we will look at the steps individually, they are interrelated and need to be not only synchronized but must be conducted as close to concurrently as possible.

Idea Generation: Ideas can come from almost anywhere.

Suppliers and Sales Force

The suppliers should be able to assist in getting ideas for improvements to the current product or new products based on the availability of different materials. Another source of ideas should be the sales force. These are the people that should have the ear of the customer. Therefore, the sales force should be the best source of what the customer wants which should then drive the generation of ideas for new or improved products.

Trade Shows

One source of ideas for products may be trade shows. There is no shortage of trade shows in operations management; everything from new product shows to emerging product shows to experimental trade shows. These shows allow company representatives to see what other companies are doing and can gauge the interest in the products from the number of people at each of the booths at the shows. Unfortunately, my experience watching people at trade shows is that too many attendees are more interested in what is being given away free rather than trying to find out what the emerging trends or products are.

Returns/Warranty Work

As we will see when we discuss Reverse Logistics, every company should be mining data and information from the returns process. This information should include why the product is coming back. Also included in this information are customer thoughts about the product and customer complaints. Another source of new product or improved product information from returns comes from warranty work. What is breaking on the current product and how can we improve the product or come out with a new product to solve these problems? This is a great source of information but should never be the primary source as this data is only available after there is an issue with the product. Another link between product design and quality.

Field Testing/Trial Users

Field tests and trial users provides companies with not necessarily the ideas for new products but provide feedback on which products the customers prefer thus giving the company an idea on which products to move forward with. Golf companies use this technique frequently. Several golf equipment companies allow golfers to “join” the companies’ testing panels. The companies then randomly select from this pool of testers to send new and trial equipment for testing. Thus far in over nine years of being on the testing panel, I have had the opportunity to "test" a golf glove. And I was allowed to keep the glove even though I "did not like it." I did not like it because they sent me a "Men's Extra Large." There was enough leather in the fingers of the glove to make another glove as my normal golf glove is a Men's Small. My friend had the opportunity to test a new Driver.

McDonalds' uses field testing to determine the acceptability of new products. For example, they tested the McRib sandwich in the Midwest. Why? Barbecue is a big deal in the Midwest. Ribs are very popular in the Midwest. Therefore, if the McRib could not sell in the Midwest there was no reason to try to sell it elsewhere (although I am not sure that the McRib is really rib meat – could be Spam with barbecue sauce). They did the same for the breakfast burrito. This was tested in the Southwest with the theory that if a breakfast burrito cannot sell in the Southwest then it will not sell in the Northeast either. They also field tested the concept of 24 hour breakfast before fielding it nationwide. In fact, Lawrence was one of the testing sites for the 24 hour breakfast.

McDonalds' has tested other products and promotions worldwide, but although they have done well in other places outside the Mainland United States, they are not staple menu items on the Mainland. In Hawaii you can buy eggs, spam, and rice for breakfast. Although this sells well in Hawaii it has not made its way to the Mainland United States yet. In Germany you can buy a Big Mac and a beer. For some reason this has not made its way to the US yet.

It used to be a common practice to place trial samples of different products in the package with the Sunday newspaper. These products included cereals, soaps, dishwashing detergent, and washing powders. The goal of these samples or field trials was to get customer feedback on the product by enticing the customer to buy more of the product and capture that data from the use of the attached coupon.

Research and Development

The most common method of generating ideas for new products and services comes from the Research and Development Departments of the larger corporations. The problem with R&D is that when the economy goes south as we saw in the 2008-2010 recession (and as it is during the COVID-19 pandemic), companies have a tendency to cut R&D expenses to save money and improve the immediate bottom line. It will be interesting to see what impacts the total shut down of 2020 will have on R&D projects.

Reverse Engineering

Reverse engineering is one method of getting ideas for products or ideas of how to make a product better and less expensive than the competition. Japan is noted for this. In the 1950s and 1960s "Made in Japan" usually meant that the product was junk. Then after a couple of decades of taking US-made products apart and reverse engineering the products, the stamp "Made in Japan" become synonymous with high quality. Japan did not invent the automobile, but they certainly learned how to make a better one; the same is true for the camera.

Benchmarking

Benchmarking may be beneficial as a means to generate ideas for improving products or processes. Benchmarking is not commercial tourism. There must be a goal of the benchmarking process. Benchmarking starts with the corporate admission that the company may not be the best at what they are doing and start the search for the “best in class” companies (companies have a problem with admitting this – think about discussions earlier of the SWOT analysis). If you are benchmarking products you must go to a competitor to benchmark against. However, if you are benchmarking a service you may be able to go outside your industry to benchmark. Many companies look to Disney to benchmark customer service. Southwest benchmarked their ground operations against the pit crew operations of NASCAR and Formula 1.

In benchmarking you sometimes need to think outside the box – maybe look outside your industry. Southwest is a good example of going outside their industry to benchmark services. Southwest has learned that to be successful in the airline industry it is imperative to have people in the seats and the planes in the air. Planes sitting on the ground can cost an airline several thousand dollars an hour. So, Southwest went to NASCAR to observe pit crews. Their rationale was that (at the time) if a Winston Cup (the top tier program in NASCAR is now just called the Cup Series) team could change four tires, make a track bar adjustment, add a round of wedge to the springs, and add 22.4 gallons of fuel in 13.9 seconds, just maybe they had some ideas that could be translated to turning planes around quicker. If the planes could be turned around quicker, more people could be flying, and more dollars could be made. They also went to Formula 1 Racing to observe their refueling operations as Formula 1 and Southwest used the same fuel nozzle for refueling operations. This is a good example of thinking outside the box for benchmarking.

Perception Maps

One final technique for determining customer desires and wants is through a perception map. Customer perceptions can be placed on an "X,Y" axis chart. The goal of the perception is to get the product into the upper right hand quadrant so that it is perceived by the customer as beneficial to them and a value for the price. Look at Figures 12.2a and 12.2b. During the product development process, a strategy must be developed to shape the perceptions of the potential customers to move the perception to the upper right hand quadrant so that the customers perceive the product to be of high quality and high value. A perception map to get the customers' perceptions of breakfast cereals could be responsible for the plethora of cereal options. The more options available, the better the probability that the perceptions of the customers will be positive and in the upper right-hand quadrant. Cheerios used to have one flavor of cereal. The issue was that although Cheerios was perceived to be good nutritionally, it was perceived to be poor from a taste perspective; as Figure 12.3 shows, Cheerios now has multiple options for their breakfast cereal influenced by perceptions and the need to design different products.

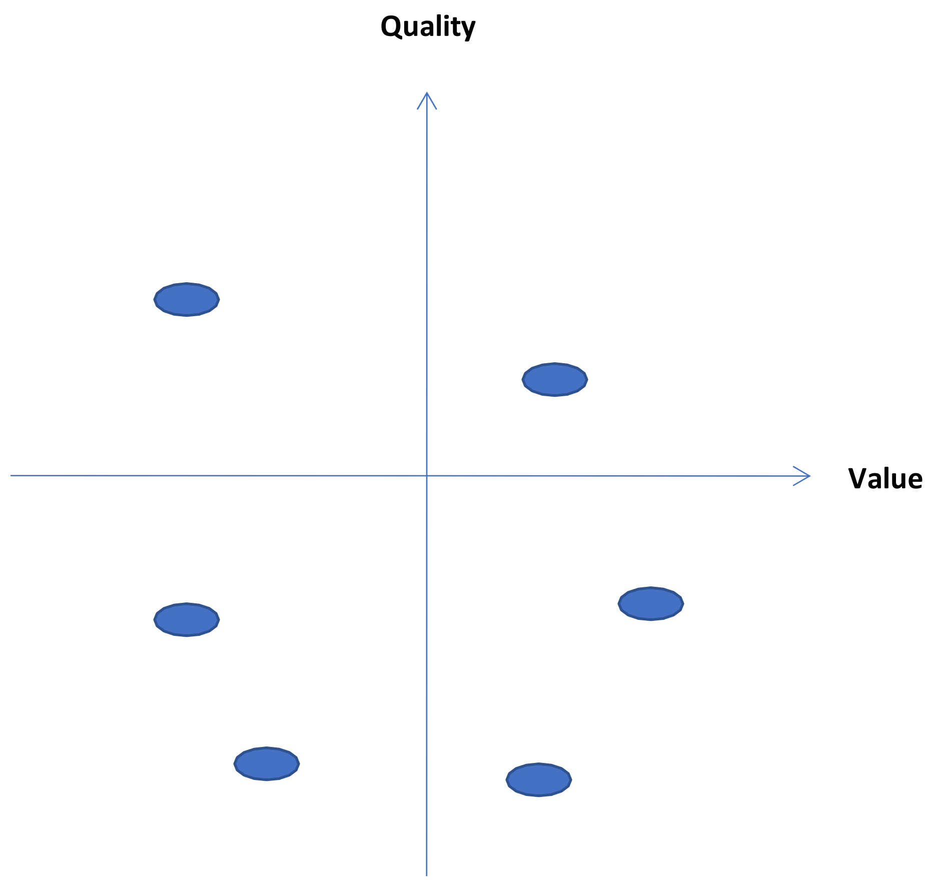

Figure 12.2a: Example of a Perception Map

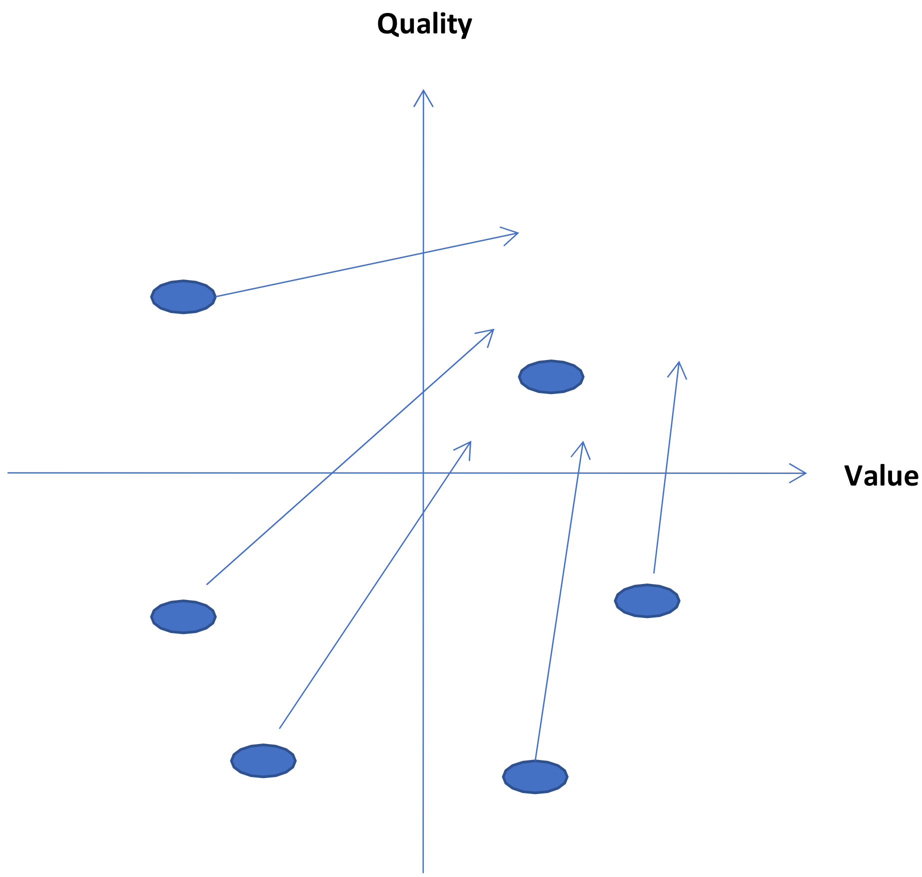

Figure 12.2b: Shaping the Perceptions of Potential Customers

Figure 12.3: Options for Cheerios

Feasibility Study

What is a feasibility study and why do we need one here? The *APICS Dictionary* defines a feasibility study as, "An analysis designed to establish the practicality and cost justification of a given project."[76] So the reason a feasibility study is needed at this point in the product development cycle is to determine the practicality of producing the new product or service.

In order to do an effective feasibility study for our product we may need to **segment our market** to determine the feasibility of producing the product for different segments of the market. General Motors used to be very good at segmenting their markets. They had Chevrolet, the "working man's car;" Pontiac, which is gone now; Oldsmobile which has been gone for a while now; Buick; and Cadillac (a winner of the Malcolm Baldrige National Quality Award) was considered the top of the line car.

Part of the feasibility study must consider the **economic analysis** of the product. In other words, can we make this product or provide this service and make a profit? If not, we cannot stay in business. This does not mean that occasionally the company will not offer a loss leader to entice customers into the store, but we cannot afford to design a product that will lose money out of the gate.

Break Even Point Analysis

While conducting the economic analysis, one of the questions that must be asked is can we produce this product and sell the necessary quantity of this product to make a profit? If so, how do we find this point (we must cover all of our fixed costs and variable costs)? This is the Break-Even Point. Equation 12.1 is the break-even point calculation. The goal is to cover all the

[76] feasibility study. APICS Dictionary app

expenses for this product (see Equation 12.2)—this is another way of looking at the break-even point.

$$\textbf{Break-Even Point} = \frac{\textbf{Fixed Costs}}{\textbf{Sales Price} - \textbf{Variable Costs}}$$

Fixed Costs = Sunk Costs (incurred even if nothing is made)
Sales Price = At what price can this product be sold?
Variable Costs = labor, electricity, materials, operating costs

Equation 12.1: Break Even Point Calculation

$$\textbf{Total Costs} = \textbf{Total Revenues}$$

Equation 12.2: Another Look at the Break-Even Point Analysis

Example 12.1 Break Even Analysis:

A company wants to design and build a new stand up paddle board. The Fixed Costs (FC) for the company are $170,000; the Variable Costs (VC) for this product (materials, labor, and overhead) are $200 per board; the projected Sales Price ($S) is estimated to be $900 each.

Break Even Point = FC/ ($S-VC)

$$\frac{\$170{,}000}{\$900/\text{board} - \$200/\text{board}}$$

= 242.86 boards (this has to be rounded to 243 as we cannot sell 0.86 of a board)

Example 12.2 Total Revenues Analysis:

Using the above information, we can do a revenue analysis for break-even analysis using Equation 12.2:

Total Costs = FC +VC(x)
Total Revenues = Sales Price(x)
Equation 12.2: \$170,000 + \$200(x) = \$900(x)
\$170,000 = \$700(x)
242.86 ~ 243 = (x)

The important thing to remember about a breakeven point is that it is simply a mark on the wall. Without a good forecast to compare it to, the breakeven point means nothing. When the forecast is compared to the breakeven point, now the company can make an educated decision on moving forward with production, cancelling the product or possibly outsourcing the manufacture of the product.

The next part of a good feasibility study is to determine whether the company has the **technical skills** available to make the product. Although the company may have the capability to produce the prototype this part of the feasibility study will determine whether the company can produce more than just the prototype or may determine that the company may be capable of designing a product that they did not have the capability of producing even the prototype. Part of this process has to be to determine whether the company can produce the product with the technical specifications of the design.

Risk Analysis

The last part of the feasibility study has to be a risk analysis of the product. In other words, can the company produce a safe product? What is risk analysis and why should you conduct a risk analysis and how should the analysis be conducted? The risk analysis must consider how the product may be used and not just the intended usage. A good risk analysis must look at the probability of something going wrong with the product and if it does, what are the severities of the impacts if something does go wrong? Part of the product development risk analysis must include identifying all of the possible hazards and if a hazard is discovered, waiting for the problem to hit the front pages of *USA Today* or on CNN is not a good idea. If a problem is identified during the testing and development, it must be addressed before the product is introduced to the public.

The steps for a risk analysis should follow this outline as provided by the US Army.

- **Identify the Hazards –** What are the potential hazards for this product? This analysis has to consider not only if the product is used as intended but must also consider the potential hazards if the product is not used as intended. For example, while designing a toy for small children, the designer must consider if children will put the product in their mouths and the associated hazards such as choking.
- **Assess the hazards to determine potential risks –** After identifying the hazards, it is important to determine the probability of the hazard occurring and the impact if the hazard does occur. Unfortunately, many risk analyses stop here because of the perception of a very low probability. For example, there was a study of the impacts on New Orleans if a Category 3/4/5 hurricane hit directly on the city. This study was done in 2004 with a caveat in the executive summary that the probability was very low – about the probability of winning the lottery. Nothing was done with the study and almost a year to the day after the study was presented to the US Army Corps of Engineers Hurricane Katrina hit New Orleans and the predictions of the study were spot on and the results matched the study

almost exactly. If the probability of an issue is greater than ZERO, the analysis must move to the next step.

- **Develop controls and make risk decisions –** What controls need to be put in place to help mitigate, minimize, or even eliminate the hazard. One option to eliminate the potential hazard may be to decide not to produce the product. If the decision is made to produce the product and the hazard cannot be eliminated, the lawyers will have to be part of the control process an help write the small print that must accompany the product inserts.
- **Implement controls –** Once the risk decisions have been made, controls must be put in place to ensure that the hazards are minimized or eliminated throughout the design and testing as well as during the manufacture process.
- S**upervise and evaluate –** This step makes the risk assessment similar to a continuous process improvement program. The goal of this phase of the risk assessment process is to make sure the decisions and controls are working. This is analogous to "we only do well what the boss checks." This step of the risk analysis process is the quality control check. Theoretically, all the risk assessment steps will be completed before the preliminary design is finalized.

Prototype Design Process

Concurrent to the risk analysis and feasibility study is the design of the product. We have already established that part of the design process is to determine how the product will look. Now we need to build the prototype. Once the prototype is completed it is time to start the testing process. This process may identify some hazards in operations that were not considered or identified during the risk assessment.

The testing of the prototype and the problems or hazards identified may lead to revisions to the design or scrapping the project all together. Sometimes as requirements change or problems are identified the prototype has to be redesigned and then retested. Sometimes the product gets stuck in a testing do-loop.

Here is an example of the testing do-loop and changing requirements. In the late 1980s the US Army was developing, testing, and was ready to produce a new variable reach forklift. This military forklift was like the blue forklifts shown in Figure 12.5. The forklift passed through the prototype development based on the requirements submitted by the potential users.

This forklift was ready for manufacture and issue to the units in the field. This was going to be the Rolls-Royce of forklifts. It was hardened against chemical attacks, nuclear attacks, and it had an enclosed cab with air conditioning and heat.

Figure 12.5: Example of Commercial Variable Reach Forklifts in Action in Kuwait, April 2003

First the Iron Curtain fell in 1989. This reduced the need for chemical and nuclear hardening of the forklift. Then Saddam Hussein invaded Kuwait in August 1990. This invasion was the impetus for Operations Desert Shield and Desert Storm. After the buildup, the short war and the redeployment process was complete, the Army decided what they really needed was a variable reach forklift that was capable of being shipped in a standard 8x8x20 foot ISO container. This would allow the forklift to be shipped in a container and be in the last containers loaded on the ship. Upon arrival as the Port of Debarkation, the containers with the forklifts would then be the first containers off the ship and then be ready to roll out and start the process to un-stuff the other containers. This required the designers to go back to the prototype design, make some alterations, and retest the redesigned prototype.

When I returned to the R&D operations for supply chain equipment in 1997, the same folks that were working on this forklift were finally ready to move the item from the testing stage to actual operations in the field for the Army. Some Department of the Army Civilians invested a large part of their careers moving this forklift through the design, prototype, testing, redesign, re-testing, redesigning and final approval of the forklift. This new forklift was ready for use for the Second Gulf War and was used along side the commercial forklifts shown above.

Reliability, Availability, Maintainability

The first time I was in the R&D operations for the US Army, the focus on designing equipment was on the Reliability and Maintainability of the equipment and not on the Availability. In retrospect this was interesting since we had a team of RAM (Reliability, Availability, and Maintainability) Engineers that were supposed to analyze every product that we designed. All three of these areas must be considered in a good design process.

Reliability

Reliability is usually expressed as a probability that the product will perform the stated time length and perform the designed and intended function during that time period. This is important to the design of the product and the claims the company will make about the product. Reliability is usually measured using the Mean Time Between Failures (MTBF)— or the average time between breakdowns or failures in the system.

Computing the reliability of a system is much like the computation some of us are familiar with from high school physics. Capacitors in a series provide a reliability that is less than any of the capacitors individually. The reliability of each capacitor is multiplied by each of the other capacitors. For example, if three capacitors are in a series with reliabilities of .95, .94, and .90 respectively would result in a reliability of 0.8037. This is like the old Christmas tree lights. If one bulb went out, the entire string would not light up and every bulb had to be tested to find the bad bulb.

Conversely, if capacitors are placed in parallel the actual reliability is greater than the capacitors individually. This is like the newer Christmas light strings that bypass the burned-out bulb with built in redundancy and finding the bad bulb becomes very easy. Part of the design process is to consider whether the added expense of built-in redundancy will make the product more reliable.

Example 7.3

If two capacitors are placed in parallel with reliabilities of .95 and .92 respectively, they will have a reliability of the first capacitor plus 1-the reliability of the first capacitor multiplied by the reliability of the second capacitor (.95 + (.92(1-.95)). In this example the reliability of the *two capacitors will be: .95 + .92(.05) = .95 + .046 = .996. This increase in reliability is the result of built-in redundancy; if the first capacitor fails, the second one will kick in.*

Maintainability

Maintainability tells the company and the customer how easy it is to maintain a product or piece of equipment. The maintainability of the product may include how much it will cost the customer to fix the product or how much it will cost the company to repair the product while it is still under warranty. The metric of maintainability is known as the Mean Time To Repair (MTTR)— or the average time to fix the product if it breaks or fails.

Availability

Availability is a combination of the Reliability and Maintainability. Availability describes the total time the product is available to the user. In the 1980s the Chevy Monza 2+2 was reliable as the MTBF was lengthy, which is a good thing, but to change the spark plugs required pulling the engine to reach the plugs. This made the MTTR rather lengthy. The metric for Availability is Systems Availability. Formula 12.3 shows the calculation for Systems Availability.

$$\textbf{Systems Availability} = \frac{\textbf{Mean Time Between Failure (MTBF)}}{\textbf{MTBF + Mean Time To Repair (MTTR)}}$$

Formula 12.3 Systems Availability Calculation

Example 7.4

A product sampling shows that the MTBF for the prototype A is 200 hours. During the testing, this product experienced several failures that resulted in an MTTR of 25 hours. The prototype B experienced an MTBF of 275 hours and the failures of prototype B resulted in an MTTR of 50 hours.

Based on the MTBF alone, the testing would have led the decision makers to choose prototype B. However, using the Systems Availability equation would lead the decision makers to choose prototype A. Always look for the highest Systems Availability – that percentage of time that the customer can use the product.

Calculations: Prototype A: Systems Availability = 200/(200+25) = .89

Prototype B: Systems Availability = 275/(275+50) = .85

Product Design and Order Winners

The product design may very well be the order winner that provides the competitive advantage. Here is an example of an order winner in the design phase—Figure 12.6 is an example of order winning advantage and taking the customer into account in the design process. The label of the bottle of wine in Figure 12.6 is printed not only in normal print but also has the label printed in Braille.

Figure 12.6: Braille Label

While the product design is ongoing, the process design must be ongoing as well. These are related events. If the two are not conducted concurrently the company may find that they have a great product and a good prototype but do not possess the ability to produce more than one of the items.

Process Design—How the Product Will Be Made and Product Design

The goal of the process design phase is to design a process of manufacturing the product that is as simple and cost effective as possible. This may mean taking the process from raw material to finished product or assembling the product from subassemblies or from modules. As the product is designed and the product design reaches the desired end state, detailed drawings or blueprints should be developed.

From these blueprints a logical production design can be developed that may drive the facility design discussed in Chapter 7. The product design and the blueprints will help develop the requirements for the tools and equipment needed to make the product. At the same time the product design and blueprints will help determine the sequence of events or activities in the manufacture process.

Traditional Product Design and Concurrent Product Design

Traditional product design is a lock-step process that moves from idea generation to engineering to manufacturing to marketing to supply chain to production. This could be a lengthy process that could be sent back to the previous step for any reason thus making the process longer.

Concurrent product design is a rather recent concept that has the goal of getting a quality product to the customers faster. Concurrent product design puts all of the players at the table together. When creating the concurrent design team it is important to have representatives from all of the stake holders' departments. By placing the right people on the team concurrently, the barriers between departments are broken down and the "do loops" that hinder product development are short circuited.

A good concurrent design team will have the engineers, the R&D folks, the manufacturing and marketing departments and the supply chain elements on the team. Accountants need to be on the team to conduct the breakeven analysis and because of the nature of today's society, the concurrent design team needs to have lawyers on the team to help draft the small print about the possible side effects or potential hazards from misuse. Some of the identified side effects of drugs advertised on television appear to create more severe problems than the original problem. It is also a good idea to improve the design of the product to get the suppliers and potential customers involved in the process.

Design For Six Sigma (also known as Design for Manufacture)

Design For Six Sigma is different from the traditional Six Sigma DMAIC steps. The goal of the design activity is to design a quality product. The goal of an individual design process is the eventual product that the team is designing. To design the right product, it is important to know what the customer wants (very similar to the first step of Six Sigma—define the customer, define what the customer wants) and how the customer defines quality. The steps of DFSS are shown in Figure 12.7.

- **Define – the goals of the design activity**
- **Measure – customer input to determine what is critical to quality from the customers′ perspective – what are customer delighters? What aspects are critical to quality?**
- **Analyze – innovative concepts for products and services to create value for the customer**
- **Design – new processes, products, and services to deliver customer value**
- **Verify – new systems perform as expected**

Figure 12.7: Design for Six Sigma

Designing for Six Sigma (DFSS) or Designing for Manufacture and Assembly (DFM) includes trying to minimize the number of parts included in the manufacture process. This may be accomplished by assembling the product from modules or subassemblies, designing the product for easier assembly, and designing the manufacturing process to minimize material handling.

Care has to be taken when using DFSS or DFM. Returning to the Ford Pinto, the goal of Ford was to place an economy car on the Mustang chassis – thus keeping with the horse motif.

As we saw above, this effort to simplify the manufacture and assembly backfired on Ford. GM saw the same issue in the 1980s with the Chevrolet Cavalier, the Pontiac Sunfire and the Cadillac Cimarron. They were the exact same cars with different medallions on the front and different price tags.

Value Analysis

Before selling the product on the open market, the company should conduct a value analysis. The goal of this analysis should be to determine if the product is perceived as a value for the price according to the customers. In assessing the value, the company needs to determine the following:

- Is there something within the product that the customer can do without? Today's computers are good examples of this. The average computer user today uses the computer for word processing, graphics, spreadsheets, and communications. There is much more that most computers can do that are not used by the average user. For the most part, today's average computer user uses his/her computer for the same purposes that my Tandy 1000 did almost 30 years ago. My Tandy 1000 had a desktop software package that had word processing and spreadsheets. This was supplemented by Lotus 1-2-3 and Harvard Graphics. Both of these programs fit on one 3.5 inch floppy disk. After Al Gore invented the Internet (he said he did while running for President in 1990 and we know a politician would never lie to us), the addition of a 300 baud modem allowed me to access the Internet. Obviously, the computer I am using today to write this is much faster and more capable, as well as much cheaper. And yet, every year a large number of users buy new computers because of the marketing campaigns and advertising for the new bells and whistles that may never be used.

- The value analysis should identify if the product is perceived as not worth the price—this may drive a different conclusion to the break-even analysis calculations.
- Is there a less expensive material or component that could be used in the manufacture of the product that will increase the value or reduce the cost of producing the product?
- Can someone else make the product cheaper or better or faster? We will discuss the options for this in Chapter13 when we discuss the make or buy decision process.
- The analysis should identify if there is another product that does the same function that is already on the market. If so, the design process needs to consider how to make this product with more value added or made more reliable and durable.

Designing for the Environment—New Trend, New Fad, or New Name for Old Process?

Designing products for the environment is nothing new. In 1969, Clemson University was trying to design a Coke bottle that would disintegrate on the side of the road after being thrown out of a vehicle. This was before “Littering Fines” became enforceable. The problem was that they could not keep the bottle from disintegrating on the shelf—which is not a good thing for grocery stores.

The latest trend in manufacturing is to design and build products that are environmentally friendly or sustainable. This is a good thing because we only have one planet to leave behind for the future generations. Designing the product that can be made from recycled or recyclable materials is an example of designing for the environment. Designing the process to make the product to use less energy is an example of designing for the environment. Or designing the packaging for the product to use fewer materials is also designing for the environment. Figure

12.8 is an example from Panama of a grocery bag that is designed to compost. Even recycling of bags is not new as grocery bags were recyclable in Germany in the early 1990s.

Figure 12.8 Compostable Bag

The Green Laws in Europe are designed to force companies into considering the environment in the design and manufacturing processes. The Europeans have been more environmental conscious than Americans for decades. While stationed in Europe in the mid-1990s it was clear that there was concern for the environment just from the amount of items that were part of the mandatory recycling program—some of which are not recycled in the United States even today. We will discuss this greater in our upcoming discussions of reverse logistics and sustainability.

Here are some examples of environmental design issues. Hewlett Packard and Xerox have determined that it is cheaper to pay for customers to return printer cartridges than it is to make new cartridges. On the flip side of this view is the disposal of carpets. Every year there are approximately four million pounds of carpets (all manmade products and recyclable) that are dumped into landfills.

Design for Distribution

This is a newer consideration in the design process. Can we design the products for ease of shipment or to get more products into the containers for overseas shipments? Think about Ikea. Almost everything that they sell is disassembled. The primary reason for this is ease of shipment. They even went as far as redesigning their coffee cups to make them stackable in the boxes in order to get more cups per box and more boxes per container. Figure 12.9 is an Ikea distribution area. You pick out the items that you want in their showroom, punch in the item SKU into a computer and an employee helps get the item for you. Consider a coffee table; if shipped disassembled it takes about ¼ of the space of the assembled table. When you start stuffing a container, the additional numbers of tables that will fit into the container is about 4 times more – thus reducing the shipping per item costs.

Figure 12.9 Ikea Distribution Area

Summary

The goal of the design process is to provide a quality product that meets the needs of the customers in a cost effective and efficient manner. While designing the product it is important to consider the Reliability, Availability, and Maintainability of the product and to design a product that will meet the necessary specifications while ensuring that the product does not fail due to poor product design.

It is the responsibility of the company to assess the needs of the customers and then determine whether the company can profitably make the product and at what point will the company start to make a profit from the product.

While designing the product it is imperative to consider how the product will be made or assembled and how the product and the production process will impact the environment. A concurrent design team should get the quality product to the market quicker with fewer, if any, necessary revisions to the product.

Thought and Discussion Questions

1. Why is designing for the environment becoming more important? Is this a recent occurrence? Provide examples of designing for the environment.
2. If a product has fixed costs of $2,000,000 with variable costs of $1200 per item with a sales price of $3,500; what is the break-even point? Why is this important?
3. Using the data from above what are the total costs at the break-even point?
4. What are the goals of the product design process?
5. Should the product and production plan be developed consecutively or concurrently?
6. What is the difference between traditional and concurrent product design?
7. What is Design for Six Sigma and how does it differ from the Six Sigma process discussed in reference to quality?
8. Can the design process provide the company with a competitive advantage?
9. What is the difference between Availability and Maintainability?
10. What is meant by the term Mean Time Between Failure?
11. What is meant by the term Mean Time To Repair?
12. If Product A has an MTBF of 175 hours and an MTTR of 25 hours; Product B has an MTBF of 250 hours and an MTTR of 60 hours; and Product C has an MTBF of 150 hours with an MTTR of 20 hours, what is the Systems Availability of the products and which one should the company select for production?