Emotional Modularity in Product Design

by

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Abstract

This thesis tests a design approach based on updateability. The research examines the effect of upgradeability options on product replacement decisions. It will attempt to prove that providing updateability in products will make people less likely to replace, and more likely to continue to use a currently owned product. In addition, the study will discuss how profit margins can be increased by lowering manufacturing costs, increasing perceived value of products, improving brand loyalty and brand image, and taking advantage of potential untapped markets. In so doing, it will attempt to identify potential problems with today's perishable product design and suggest methods to avoid them.

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Brian T. Williams

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List of Abbreviations

ATM	Automatic Teller Machine
AV	Audio/Visual
CPU	Central Processing Unit
CD	Compact Disc
D/C	Direct Current
DDT	Dichlorodiphenyltrichloroethane
DVD	Digital Video Disc
DVI	Digital Video Interface
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
GUI	Graphical User Interface
HDMI	High-Definition Multimedia Interface
IDSA	Industrial Designers Society of America
LCA	Life-Cycle Assessment
LCD	Liquid Crystal Display
PCB	Printed Circuit Board
RAM	Random Access Memory
RCA	Radio Corporation of America

SIM	Subscriber Identity Module
TCSA	Toxic Substance Control Act
USB	Universal Serial Bus
VHS	Video Home System

CHAPTER 1: INTRODUCTION

Need for Study

Products of today are designed with excess durability. The product is designed to outlast its usefulness. This hurts the user, who feels that he or she has to buy a new product of the same type before the incumbent possession has worn out, or becomes technologically obsolete. It also hurts the planet. Billions of tons of hazardous waste material are created, and a staggering amount of energy is consumed during the production and distribution of products annually. Resources are being depleted, misused, underappreciated, and then disposed of. Current methods of dealing with these problems (such as recycling, the use of “green” materials, or chemical treatments for example), only serve to damage a bit less, and can end up causing new problems. The reality is that we are doing very little about the waste that we produce. What cannot be recycled or re-used, dissolved, or incinerated is simply dumped into a landfill and covered up.

With population growing so quickly, and product life spans so fleeting, the rate at which products and their packaging will be discarded will grow at an alarming rate. The solution to this problem lies in the designer’s ability to think in terms of what they can deliver to the user and how best to deliver it. The most sustainable product – or component – is the one that never has to be produced in the first place. New methods must be used to quench the user’s thirst for new experiences, not by providing a newer and shinier object, but rather by delivering new and evolving user-product relationships. With government restrictions and regulations becoming more stringent, and public opinion shifting toward more eco-minded thinking, new sustainable design strategies will become more and more important.

Objective

This study will identify ways to design products that are modular, updateable, upgradeable, and long lasting. Post-purchase consumables such as services and upgrades will replace "this year's model." It will also attempt to show that this approach to sustainable design will be capable of improving brand loyalty and brand image, and increasing the perceived value of products. This study will provide designers with a new set of tools and strategies that they can use to help their clients stay competitive.

Assumptions, Scope, and Limitations

It is logical that there will be certain things that are assumed to be true. This includes all information from published sources (e.g., studies on psychology by experts in their respected fields). Any subject testimony obtained during tests will be assumed true. Samples of the population studied will be accepted as representative of the whole. Any census information taken from a reputable source, such as the US government, can be assumed to be true as well. Any opinions or observations from the writer are assumed to be representative of the whole. These include, but are not limited to the following: "We are an overly materialistic society"; "Products should bring people together, not isolate them"; "Designers have a duty to design with people, and the environment in mind"; "The present model of accepted obsolescence is unethical and negligent."

It also becomes necessary to acknowledge that there is a limited scope for this project. It would be impossible to test all of the aspects of this issue in the given time frame. The tests and research will only explore the characteristics of products or services that lead to long lasting, emotionally durable product life spans. It will not cover the economic feasibility of implementing the methods developed within. No foreign markets will be explored, nor will the research cover every product genre. The research will not try to prove or disprove any accepted psychological theories.

There are certain limits placed upon this project. Current results of similar tests in the same field as this study already yield important data. Time restricts testing to prove or disprove them. Due to financial and time restraints, testing will be conducted within the city of Auburn, AL. Lack of funding prevents experiments in which subjects use new products. The time frame for the research will not allow any long-term verification of results.

CHAPTER 2: THE PROBLEM

The Overly Materialistic and Wasteful America

Modernization began to change our rural societies to a globalized industrial society in the mid eighteenth century. Consequently, since the mid eighteenth century, people have destroyed more of nature than in all prior human history. The ever increasing need to consume resources and pollute for the sake of production has led to a runaway ecological problem. In the late nineteenth century, the move from man-powered to mechanized industry meant that factories could now produce more than could actually be distributed and consumed. Since, America has been suffering from overproduction. American businessmen worried how to avoid this problem of overproduction, not by producing less, but by selling more. They concentrated on the lack of demand and effective distribution in a twofold attack on the problem. While mail order companies such as Sears, Roebuck, and Montgomery Ward were creating effective distribution networks, manufacturers took on the challenge of slack demand with innovative marketing techniques intended not only to influence more people to buy, but also for people to buy repetitively (Slade 10).

Solutions to the problem would eventually include branding and trade marking, packaging, creating disposable products, and designing in planned obsolescence. Marketing departments began to ask the question, “How can we get consumers to return for our product over and over again?” Packaging design was a way of differentiating one’s brand from the growing number of competitors on the shelf. Quality control measures assured the customer that a particular brand of products would be of a known quality. Successful advertising would be important to creating repetitive consumption. The spread of home radio, and eventually television, provided a great medium for advertising. Repetitive advertising continues to be a powerful influence on psychological obsolescence that makes people think they need a "newer, shinier object."

World's Oldest Brand

Lyle's Golden Syrup has been named as Britain's oldest brand, with its green and gold packaging having remained almost unchanged since 1885.
Image from: http://www.restaurantwidow.com/images/lyles_1.jpg
Fig 1

The term "obsolescence" was first coined in the early twentieth century to describe out-of-date products. When the electric starter appeared on automobiles, it rendered the old technology obsolete overnight. Technological obsolescence is somewhat unavoidable as civilization advances, but planned and perceived (or psychological) obsolescence are business strategies developed to create more demand for products (Slade 4). As manufacturers learned to exploit obsolescence, customers became more accepting of it in every aspect of their lives. This led to a "throw-away ethic" or "disposable culture" in the early nineteenth century.

"Deliberate obsolescence in all its forms—technological, psychological, or planned – is a uniquely American invention. Not only did we invent disposable products… but we invented the very concept of disposability itself, as a necessary precursor to our rejection of tradition and our promotion of progress and change" (Slade 4). King Camp Gillette, and his invention of the safety razor in the late nineteenth century, ushered in the age of "freebie marketing"—in which an item is given away for nothing or at an extremely low price to ensure the sale of another, generally disposable item (Martin). Using the slogan “No Stropping. No Honing,” Gillette’s razor won favor among the American people due to its sanitary aspect. Gradually, this disposable culture began to spread to other goods outside of sanitary items, from paper collars, to wrist watches.

Americans began to display an ambivalent attitude towards waste and thrift. Hoarding had become a bad word. In the period between the two World Wars, stodgy older values were rejected in favor of extravagance. Our culture was changing from an ethic of durability and thrift, to a disposable one.

Just as manufacturers were learning how to exploit obsolescence, critics were speaking out against it. In the 1950’s and ‘60’s, critics such as Vance Packard, pointed out how advertising was using research to learn to manipulate buyers, and the media was creating artificial needs in vulnerable consumers. A few decades later, in the article “The Political Economy of Culture”, sociologist Sut Jhally writes, “the industries that produce culture attempt to instill a particular consciousness in the public. Advertising convinces people that they are happier when they acquire new things, and that if we do not acquire new things, we have no value in society.” Jhally goes on to say, “Media venues do not sell entertainment or information: They sell audiences to advertisers” (Jhally).

While many understood as early as the 1950’s what effect this excess materialism had on our culture, people are just starting to acknowledge the impact of this excessive consumption upon the Earth and its ecological systems. We are doing damage to these delicate systems at a far greater rate than they can repair themselves. If something is not done to curb this reckless destruction, people may face a future of turmoil as the Earth struggles to regain stasis. Recent environmental awareness has led many to ask the question, “What are the environmental impacts created by this repetitive consumption?” There are impacts in each of the phases of product life

Fig 2

Victims of Rampant Consumerism

Photo of Brazilian children standing in a recently burned field.

Image from: http://earthobservatory.nasa.gov/Features/Deforestation/Images/slash_and_burn_children.jpg

Rain Forrest Soil

The organic material and nutrients in a tropical rainforest are found in the vegetation itself, not in the soil. This eroded hillside along a river in Amazonia shows the infertile soil typical of tropical environments (pinkish-tan) topped by a very thin layer of fertile soil and forest detritus (brown).

Image from: http://deoxy.org/img/amazon_soil.jpg

Fig 3

cycle: extraction and processing of raw materials, manufacturing, distribution, sale, use, and end-of-life. These impacts can be on human health, climate change, habitat destruction, resource depletion, etc.

Since the Industrial Revolution, wood has been one of most consumed natural resources. The growing appetite for wood (and in some cases the minerals buried under the trees) for fuel and raw materials caused rampant deforestation. We are losing sixteen million hectares per year. This is more than the total area of New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, and Delaware combined per day.

The world has already lost half of its original forests ("Global"). Rainforests full of medically beneficial plants are being burned to bare ground. As a result of deforestation, we are losing between 50 and 100 animal and plant species each day (N. Myers 12).

Logging, mining, and farming in tropical forests sometimes displace indigenous communities which have existed in perfect balance with their natural world for tens of thousands of years. Left without land or other resources, native cultures often disintegrate. Despite logic, tropical environments typically have very infertile soil, making farming difficult (see Fig 3). Without the nutrients provided by the biology, nothing can survive there. This means that the impact of deforestation on the way of life of indigenous people, plants, and animals is exceptionally harsh.

Rain forests are not the only ecosystems under attack. Seventy five percent of all the fish stocks in the world are already exploited, over-exploited, or recovering under governmental protection, and ninety percent of large fish species have been depleted since 1950 (R. Myers 280). Compounding the effects of over fishing are the effects of the destruction of the coral, plant, and microbial life that supports most of marine biology due to climate change and chemical pollution. About one third of the chemicals released during manufacture of products and electrical energy, and the use of synthetic pesticides, eventually settle in the ocean after being transported by rivers or scrubbed out of the air by rain (Gore 164). Sixteen percent of coral reefs were lost in 1998 alone (Gore 164). The world has lost much of its coastal wetlands, including mangrove swamps and salt marshes. Recently, natural disasters from hurricanes to tsunamis have decimated vast coastal areas. Many scientists believe that the changes in weather patterns are the result of global warming, and we will continue to see more extreme change as the temperature rises. The predicted range of climate change by 2050 will place fifteen to thirty five percent of the 1,103 species studied at risk of extinction (Thomas 145).

We are depleting natural resources such as fossil fuels, minerals, and fresh water. Fresh water is something that most of America takes for granted, as it exists in large quantities across most of the country. However, it is a valuable and increasingly exploited natural resource, and is necessary for most forms of life on the planet. Much of the world would shudder at the way we use water in what must seem to them very wasteful habits, such as watering our lawns or even taking frequent baths or long showers.

Minerals such as silicon, iron, lead, nickel, cadmium, aluminum, zinc, copper and many others are essential for the production of the technology we use on a daily basis. While electric powered vehicles may help reduce our dependency on oil, they require the mining of massive amounts of heavy metals for batteries. These mines are often located in less developed areas where poverty motivates people to work in harmful conditions for little pay. Safety regulations are often not as stringent, or not present at all in these underdeveloped countries, where mining accidents kill thousands of people each year. For example, a gas explosion in northern China killed 105 people on December 5, 2007. The government said two mine officials, including the head of the mine, were being held by the police (New York Times). The mine was operating without any safety license and the Xinhua News Agency claimed the cause was incorrect usage of explosives. In addition to damage caused to the human population, these mines often disrupt large ecosystems.

In a world economy based on fossil fuels, oil is extremely valuable. The use of automobiles in America contributed to the consumption of roughly 400 million gallons of gasoline in 2006 (“Biofuels”). The value increases in proportion to demand (which is increasing), and supply (which is decreasing). The result is that the search for minerals and fuel sources has become very profitable, and therefore very aggressive, and will become more detrimental to the environment as demand increases.

This aggressive hunt for oil led to one of the worst environmental disasters in United States history in the form of a massive oil leak into the Gulf of Mexico in the summer of 2010 known as the Deepwater Horizon spill. Conservative estimates are that at least 4.9 million barrels of oil (plus or minus ten percent), as well as natural gas, gushed into the Gulf of Mexico completely unhindered for eighty six straight days. British Petroleum (the oil company responsible for the spill) angered many Gulf Coast residents in their attempts to downplay the disaster, and their environmental and economic responsibilities. BP's reaction reflects a common attitude among industrial powers; money is the most important driving factor in decision making.

The Gulf Coast horizon is littered with offshore oil rigs. The insatiable quest for resources does not end at the shoreline, or even at the oceans, as there is even talk of exploring the moon for minable materials, and starting the spread of destruction outward through the solar system. Although, at this point mining other celestial bodies is completely out of our technological grasp. These practices will happen with increasing frequency as people become more and more accustomed to the easy availability of our natural resources.

Massive amounts of embedded energy and resources are used in the extraction and transportation of fuel and resources that drive industrialized economies. This comprises a large percentage of the carbon footprint associated with the product industry. Then "we use [more] energy to mix toxic chemicals in with the natural resources to make toxic contaminated products… In the U.S. our industry admits to releasing over four billion pounds of pollution per year" (Leonard). The air pollutants produced by the manufacturing facilities and the massive fleets of vehicles involved in the distribution of products contribute to global warming. These pollutants range from carbon dioxide to nitrogen trifluoride – a powerful greenhouse gas with a potential impact on climate change 17,000 times greater than carbon dioxide, and a common gas used in the production of liquid crystal display (LCD) televisions (Leonard).

As of today, conservation efforts emphasize recycling most plastics, glass, and metals, and putting restrictions on how much waste a given process should produce. These policies only serve to damage the earth "a bit less," and do nothing to address the growing population and their growing waste production. Fresh Kills Landfill in New Jersey (the largest landfill in the world until its closure in the year 2000) reports that hot dogs, corncobs, and newspaper are still recognizable after twenty five years, and the paper was still readable. It is clear that the anaerobic conditions of the landfill are not conducive to biodegradation. The waste is not going anywhere, and it will continue to leak toxins such as dioxin - a human carcinogen that is toxic in very low amounts - into the ground water, and off-gas toxins into the air for generations to come. If the population continues to grow and consume at this rate we will eventually bury ourselves in garbage.

What causes this rampant waste production? "Consumption and waste are born primarily out of an inappropriate marriage of excess material durability and fleeting product-use careers" (Chapman 7). A mini-disc player will take over five hundred years to decompose in *perfect* conditions. This is because the materials (such as plastics) have been chemically manipulated from their natural state to the point where they are no longer recognizable to the microbes that break down natural materials. On the other hand, the technologies that support our electronic devices are designed to be obsolete in just a few years. In the case of the mini-disc player, the format never caught on in the first place and these systems were obsolete almost as soon as they were released.

Some products are discarded before they are physically worn out because their design is out of fashion, or are inappropriate for changed circumstances (as in the case of the mini-disc player). "When objects befall misuse in this way, we begin to see an alternative to the conventional model of obsolescence, in which goods are nullified by substantial shifts in technology, format, or other operational protocol. Rather, obsolescence is also a consumer-side issue driven by the failure of the product to quench the human thirst for new, fresh experiences" (Chapman 47). This psychological obsolescence leads to massive amounts of waste when perfectly usable products are discarded.

The Psychology of Human Consumption

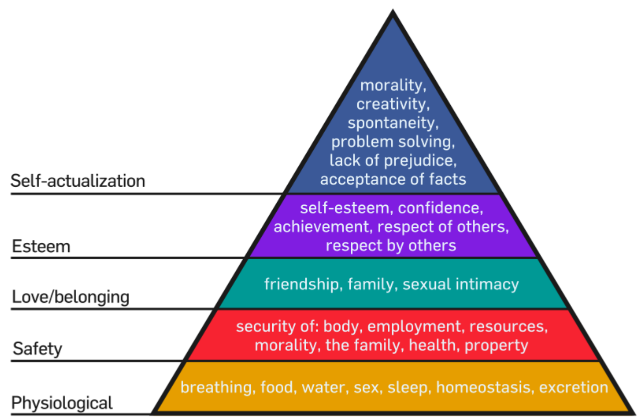
Humans consume. We consume the things we need, such as water, food, oxygen, etc. We also consume the things we want, and we consume them in quantity. What causes this rampant consumerism? There seems to be a quality of human nature that makes us want to seek new experiences. Whether we are driven by some instinct, conditioned by the media, or are just bored, it seems that we have a powerful urge to consume.

Sometimes we buy something to make our lives easier. When a new technology becomes available, such as cellular phones, it can improve our lives by bringing a new level of convenience. People will no doubt be very keen to obtain this new technology. There is a rush amongst the "early adopters" to try the newest thing. There is then a "social cascade" effect whereby others, more resistant of new technology, rush out to buy one, either to be right, or to gain social acceptance (Slade 260).

However, not everyone who buys a cellular phone is buying it out of necessity. In fact, it is more likely that the buyer is replacing one that they already have, one that still provides nearly the same functionality as the one they are buying. Many cell phones that people replace and discard are still being sold in retail stores as new models. "By 2002, over 130 million still-working portable phones were retired in the United States… Cell phones [have] the shortest life cycle of any consumer electronic product in the country. In Japan, they are discarded within a year of purchase" (Slade 263). Why would someone buy a new phone when they already have one that functions just as well as the day it was purchased? The desire we feel to buy something may not be driven by the need for the function of a product, but rather a need for a new experience.

Beyond the need for function in a product there is a human need for deeper connections. In the hierarchy of human needs developed by Abraham Maslow (see Fig. 4), needs are categorized and grouped as shown in the figure to the right; once an individual has moved upwards to the next level, needs in the lower level will no longer be prioritized. If a lower set of needs is no longer being met, the individual will temporarily re-prioritize those needs by focusing attention on the unfulfilled needs, but will not permanently regress to the lower level. For instance, a businessman at the esteem level who is diagnosed with cancer will spend a great deal of time concentrating on his health (physiological needs), but will continue to value his work performance (esteem needs), and will likely return to work during periods of remission. Once we have taken care of our physiological needs, such as food, water, etc., we then seek to take care of our psychological needs, such as the

Maslow's Hierarchy of Needs



Maslow's hierarchy of needs is a theory in psychology, proposed by Abraham Maslow in his 1943 paper "A Theory of Human Motivation."
Maslow's hierarchy of needs is predetermined in order of importance. It is often depicted as a pyramid consisting of five levels: the lowest level is associated with physiological needs, while the uppermost level is associated with self-actualization needs, particularly those related to identity and purpose. The higher needs in this hierarchy only come into focus when the lower needs in the pyramid are met.
Image from:
http://www.mba-tutorials.com/wp-content/uploads/2010/01/Maslow_Hierarchy_of_Needs.jpg

Fig 4

need to be loved. These needs impact us on a much deeper level than lower needs. A piece of fine art or a well-designed product can evoke some of this psychological pleasure.

Another hierarchy of human needs, derived from Maslow's, is that of Patrick Jordan, author of *Designing Pleasurable Products*. This hierarchy of consumer needs outlines human needs as they relate to product design. In his model, the functionality is the basic level. A product needs to fulfill a particular function, and perform this function quickly and reliably. Once people have become habituated to products having a particular functionality, they then want them to become easy to use. Frustration caused by bad ergonomics, or a poorly designed user interface, can render the functionality of the product useless. When users have become accustomed to highly usable products, according to Jordan, people will then want products that offer not only functional benefits but also emotional ones.

This means that to create a product with a positive user experience, the product must perform a useful function for the user, and this functionality must have a high level of usability. Only after these two criteria have been met can a product offer a real emotional connection, and create an experience that is both pleasurable and memorable. This emotional durability offered by a positive connection with the user will create hesitation when considering whether or not to replace the product with a new one.

When consumers contemplate replacing an important possession, they frequently must resolve several issues related to the replacement task. The decision to replace a car, for example is likely to invoke consideration of costs and benefits of keeping or disposing of the vehicle one already owns, evaluation of the adequacy of the decision maker's financial resources and garage space, consideration of the household's short- and long-term consumption goals, values, and a host of other situational factors, such as social acceptance (Roster 48).

The decision making process becomes a product of two sub-decisions; the retention of the currently owned possession, and the acquisition of a replacement. Therefore if a suitable upgrade for a product can be offered, it should decrease the perceived need to replace an incumbent possession. It is the designer's job to offer products with these updateable experiences.

Branding and Marketing

iPod Advertisement

Apple's iPod ads are meant to highlight the social and psychological aspects of owning one, and offer no information about the performance or durability of the product itself.
Image from:
http://www.chailife.com/wp-content/uploads/ipod_commercial.jpg

Fig 5

Branding was created in the early twentieth century to deal with product surplus created by excessive manufacturing. Marketing professionals ever since have worked to convince people to buy their brand of product over other competitors. Customers associate logos and trademarks with products of a certain quality. Marketing is about convincing people that a particular brand offers the *only* solution to their needs. Curiously, marketing and branding are rather non-logical in that the brand promise often has very little to do with the products themselves. Apple's advertising of the iPod, for example, in which there are silhouettes dancing against a colorful background, conveys nothing about the physical product, but rather the social and emotional benefits of owning an iPod (see Fig.5).

In the case of the iPod, the promise delivered by the brand is meant to serve the users' higher needs in the hierarchy, rather than on the usability or functionality of the product. The iPod's ad campaign is meant to highlight how "fun" and "exciting" the product is and to appeal to people with active lifestyles. This marketing approach has been very successful at selling products that are designed for planned obsolescence, such as the iPod. New "models" of the iPod (essentially the same product) are released almost yearly, as a way of manipulating consumers into repetitive buying.

Marketing is a rather dehumanizing profession. People are referred to in non-human terms, and manipulated for the profit of others. A marketing professional's attitude toward potential customers can be assessed by examining the vocabulary they use. Industrial designers use the term "users" to describe those who buy the products we design. This reflects a focus on the user's experience with the product, referring to the customer in more human terms. Marketing calls these buyers "consumers," highlighting the different relationship with the consumer from that of the designer. The fact that they are *consuming* their products is significantly more important than how or why they may be *using* their products. Whether or not the consumer actually *needs* the product is of no concern to the marketer. Indeed it seems that marketing departments want to see someone buy a cell phone when they don't really need one; with little or no concern for the waste issues that accompany this type of consumption.

Marketing departments rely on "perception" to sell to as many people as possible, as many times as possible. Perception is determined by exposure to, and interpretation of the product. They break down consumers into different demographics and market segments, and analyze how to best manipulate the behaviors of these groups. How they react to the "stimuli" (i.e., advertising and shelf presence) determines whether they will buy or not. They use processes such as repetitive and subliminal advertising to condition people to buy.

"Surprising stimuli are likely to get more attention—survival instinct requires us to give more attention to something unknown that may require action" (Perner). Therefore, new products get more attention on shelves than a product that the shopper is used to seeing. A product that stands alone in the crowd will probably be noticed, but noticing a product is not enough. The goal of the marketing department is for the customer to *buy* the product. Once the product is bought, the marketing department's job is over. It is the designer's job to make sure that the customer has a positive experience with the product after the sale.

Once a consumer has purchased a product, a positive experience is necessary to enhance brand image and loyalty. A new product will likely sell slow at first, and then pick up speed later. This makes it important for initial users to have positive perceptions of the product. Exposure leads to attention, and attention can change attitudes.

Given that a person's attitudes toward a given product improve over time, it would make sense to strengthen bonds with products that users already own, rather than to try and get them to buy an entirely new one. Services and upgrades can be offered as consumables to users to update the product experience, making them more likely to want to retain the currently owned artifact.

The materialistic and wasteful attitudes displayed by consumers lead to widespread waste and ecological destruction. These attitudes are caused, in part, by the constant stimuli provided by advertisers and society, and also by the psychological need of consumers to achieve higher levels of fulfillment. It is important for designers to fill these needs while creating the most environmentally-friendly products possible.

CHAPTER 3: A SOLUTION

Cradle to Cradle

In the book *Cradle to Cradle*, William McDonough and Michael Braungart discuss why "being less bad is no good." McDonough and Braungart argue that the current policy of eco-efficiency is fundamentally flawed. The authors suggest a closed loop "cradle to cradle" approach in which waste becomes raw materials for new products that will circulate endlessly within industrial cycles – "eco-effectiveness".

Eco-Efficiency

Dating back to the industrial revolution, destruction and pollution have been regulated to prevent immediate sickness and death of those living and working in or around factories (McDonough 45). For nearly two centuries, environmental concerns about reckless and rampant production went largely ignored. It was not until the publication of Rachael Carson's *Silent Spring* in 1962 that romantic environmentalism merged with legitimate scientific concern, especially over manmade chemicals – DDT in particular (McDonough 47). This concept actually dates back to the beginning of industrialization. Since then, efforts to minimize destruction and waste have centered on a "cradle to grave" model, in which a product eventually ends up in a landfill (or is carelessly discarded onto the ground or into a lake, river, or ocean). Familiar to many, the three R's – *reduce, reuse*, and *recycle* – embody this linear philosophy.

In 1992 at the Rio Earth Summit, approximately thirty thousand world leaders and representatives from one hundred sixty seven countries met in Rio de Janeiro to respond to signals of environmental decline. No binding agreements were reached, but one major strategy emerged from the participants – *eco-efficiency*. Simply defined, eco-efficiency means "doing more with less" (McDonough 51).

McDonough and Braungart discuss in detail the *four* R's that define eco-efficiency (reduce, reuse, recycle, and *regulate*), and the problems associated with them. "Whether it is a matter of cutting the amount of toxic waste created or emitted, or the quantity of raw materials used, or the product size itself (known in business circles as 'dematerialization'), reduction is a central tenet of eco-efficiency. But reduction in any of these areas does not halt the depletion and destruction – it only slows them down, allowing them to take place in smaller increments over longer periods of time" (McDonough 54). Studies have shown that even tiny amounts of dangerous emissions can have disastrous effects on biological systems and human health. A 1995 Harvard study found that as many as 100,000 people die annually in the United States as a result of particulates (McDonough 54). "In Hamburg, Germany, some trees' leaves contain such high concentrations of heavy metals from incinerator fallout that the leaves themselves must be burned, effecting a vicious cycle with a dual effect: valuable materials, such as these metals, bioaccumulate in nature to possible harmful effect and are lost to industries forever" (McDonough 55).

Reusing waste may just transfer harmful materials from one place to another. Composting or using waste as fertilizer can present problems. When materials are chosen to be composted, the chemicals in these materials can be introduced into the environment. "Even residential sewage sludge that contains toilet paper made from recycled paper may carry dioxins. Unless materials are specifically designed to ultimately become safe food for nature, composting can present problems as well… In some cases it may actually be less harmful to seal the materials in a landfill" (McDonough 56).

McDonough and Braungart also address recycling. They argue that a more accurate term is *downcycling*, as the quality of the material is reduced each time it is recycled. When materials are recycled, they are mixed with small amounts of different materials that can degrade the quality. "Currently there is no technology to separate the polymer and paint coatings from automotive metal before it is processed; therefore, even if a car were designed for disassembly, it is not technically feasible to 'close the loop' for its high quality steel" (McDonough 57). The paints and plastics that are melted into recycled steel can contain harmful chemicals that can increase contamination of the biosphere as well. The creative use of recycled materials can create unforeseen disadvantages. For example, clothing containing fibers made from recycled plastic bottles may be treated with chemicals to make the fibers perform in their new role. They can "contain toxins such as antimony, catalytic residues, ultraviolet stabilizers, plasticizers, and antioxidants, which were never intended to lie next to human skin" (McDonough 58). Attempting to recycle products that were not designed to be recycled can result also in additional operating costs.

Regulation, the authors argue, is a system at war with itself. On one side is the regulator (the government that serves to protect its constituent population), and on the other side is economical commerce. “Money, the tool of commerce, will corrupt the guardian [government]. Regulation, the tool of the guardian [government] will slow commerce” (McDonough 60).

> An example: a manufacturer might spend more money to provide an improved product under regulations, but its commercial customers, who want products quickly and cheaply, may be unwilling to absorb the extra costs, they may then find what they need elsewhere, perhaps offshore, where regulations are less stringent. In an unfortunate turnaround, the unregulated and potentially dangerous product is given a competitive edge (McDonough 60).

Eco-efficiency is a policy that only serves to make a destructive system a little less destructive. The authors of Cradle to Cradle argue that, “In some cases, it can be even more pernicious because its workings are more subtle and long term. An ecosystem might actually have more of a chance to become healthy and whole again after a quick collapse that leaves some niches intact than with a slow, deliberate and efficient destruction of the whole” (McDonough 62).

CHAPTER 4: A MORE EFFECTIVE SOLUTION

Eco-Effectiveness

As discussed in Chapter One, the current policy of eco-efficiency is unsatisfactory. McDonough and Braungart are inspired by natural processes that are not *efficient*, but rather *effective*. An excerpt from *Cradle to Cradle* states:

> Consider the cherry tree: thousands of blossoms create fruit for birds, humans, and other animals, in order that one pit might eventually fall onto the ground, take root, and grow. Who would look at the ground littered with cherry blossoms and complain, "How inefficient and wasteful!" The tree makes copious blossoms and fruit without depleting its environment. Once they fall on the ground, their materials decompose and break down into nutrients that nourish microorganisms, insects, plants, animals and soil. Although the tree actually makes more of its "product" than it needs for its own success in an ecosystem, this abundance has evolved (through millions of years of success and failure or, in business terms, R&D), to serve rich and varied purposes. In fact, the tree's

> fecundity nourishes just about everything around it (McDonough 72).

This natural "factory" is the opposite of efficient, yet the overproduction and "waste" is actually *better* for the surrounding ecosystem. The environmental factors that have shaped the behavior of the tree for so long have designed a system that actually nourishes with its waste, rather than poisons; that provides for its surroundings rather than destroying them. If the policy of eco-efficiency was applied to the cherry tree, it would produce fewer blossoms and fewer trees; it would scrub less carbon dioxide and produce less oxygen; and it would offer less pleasure to us as humans. As designers, we should be inspired by nature's complexity and intelligence and expand our vision from the primary purpose of a product or system and consider the whole. "What are the goals and potential effects, both immediate and wide-ranging, with respect to both time and place? What is the entire system – cultural, commercial, and ecological – of which this made thing, and way of making things will be a part?" (McDonough 82).

Waste Equals Food

A central tenant of *Cradle to Cradle* is that in a perfect closed-loop system, the waste from one course becomes food for another. The biological system exemplifies this model, and for millions of years it was the only system on the planet, of which all things on Earth, both living and nonliving, were a part. Industrialization altered the natural equilibrium; concentrating, altering and synthesizing natural materials into materials that cannot be safely returned to the soil. "Now material flows can be divided into two categories: biological mass, and technological – that is, industrial – mass… Biological nutrients are useful to the biosphere, while technical nutrients are useful for what we call the *technosphere,* the system of industrial processes. Yet somehow we have evolved an industrial infrastructure that ignores the existence of nutrients of either kind" (McDonough 92).

The authors attempt to impart an understanding that a product at the end of its life cycle should provide technical nutrients (or biological nutrients) for future systems. With the advancement of biodegradable materials, it becomes easier to see how a product made from synthesized materials can provide nutrients by composting it. However, as discussed earlier, these synthesized materials may cause unforeseen damage by returning them to the soil, as nature never intended the elements in the material to be combined in this way. Returning an unnatural material into a natural process has created problems of incompatibility.

How then, can we attempt to provide a product which will provide viable technical nutrients for future products? The answer requires us to think about the problem from a systems standpoint, examining all aspects of the product and its constituent components throughout time, rather than a narrow minded solution based on solving one problem. The following sections in this chapter will attempt to provide design solutions to this problem.

Design for Updateability

If the desire to keep using a currently owned product is stronger than the desire for a new replacement, the user will continue to use the incumbent product, and vice versa. This sounds basic, but it can be very complicated. In the case of the decision on whether or not to buy a new car, the decision hinges on many factors such as: costs and benefits of keeping or disposing of the current car, adequate financial situation and garage space, the household's short and long term consumption goals, and other situational factors such as social influence. "In short, replacement decisions involving durable possessions can be quite complex" (Roster 48). In Their study, "Ambivalence and Attitudes in Consumer Replacement Decisions," Catherine Roster and Marsha Richins propose that "replacement decisions [involving durable goods] are based on two parallel, but integrated suborder decisions involving, on one hand, the continued retention of a currently owned possession, and on the other hand, the acquisition of a replacement product."

The proposal goes on to say, "When contemplating a replacement decision, three alternatives are typically available. The consumer may (1) acquire a replacement product and dispose of the incumbent possession, (2) acquire a replacement and keep the incumbent, possibly moving it to a new role in the household, or (3) engage in decision avoidance, in which the consumer postpones the decision or seeks a solution that involves no action or charge" (Roster). This study implies that customers may be less likely to replace a currently owned product if a suitable and relatively inexpensive upgrade

Microsoft Surface

Image from: http://www.techpowerup.com/img/08-04-02/Surface_ATT_3863.jpg

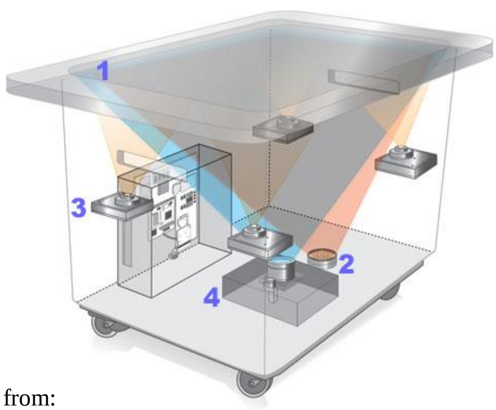


Image from: http://www.radupoenaru.com/wp-content/uploads/microsoft-surface-diagram.jpg

The Surface computer is a table-top LCD that can be used by multiple users at the same time. The new product is aimed at hotels, retail stores, restaurants, and public entertainment venues.

The system can recognize touch as well as certain objects placed on the screen (1). A projector (2) shines near infra-red light through a diffuser. This light is reflected down and mapped by four infra-red cameras (3). The projector (4) displays on an area slightly smaller than the infra-red footprint to allow for better recognition at the edges. The system also allows wireless transfer of data with some devices.

Fig 6

or update is available for the incumbent product. Logically, products should be designed for upgradability and updatability.

For the purposes of this discussion, an upgrade will be defined as an improved component or software that replaces another outdated component or software to improve the function of the product. An update will be defined as a component or software change that allows the product function properly in response to changes in technology or other factors.

Design for upgradeability might mean changing to a software based product to better adapt to a wide variety of unforeseen scenarios, or simply allowing for individual components to be changed when better alternatives become available (higher resolution, more memory, etc.). This is especially true in the electronics industry, where Moore's Law dictates that the performance of electronic products doubles about every two years.

Upgrades and updates can deliver the new experience that is driving the need to replace a purchased good, without the associated costs and resources used. Changes in interface, for example, can provide the new user with the feeling that they are using something new. Microsoft's "Surface" technology illustrates that a change in interface can create the feel of a brand new product, even though the computer that is running the program is little or no different than the one used to type this paper (See fig 6). The "cool factor" that may be influencing a decision on whether or not to replace something can be delivered through upgrades of components (such as a monitor in the case of Surface) of the whole system. The goal is to offer a new experience while using as few new components as possible.

As with all sustainable strategies, design for updatability must be considered during the earliest stages of the design process. A designer should have his or her finger on the pulse of emerging technologies in their respective fields, and design products that can be upgraded to meet these needs when the time comes. Xerox requires instructions for end-of-life disposal or recovery, along with anticipated life spans, with every part drawing (Maslennikova 229). This forces designers to consider the entire lifespan of the product and its individual parts from manufacture through its use and eventual replacement, and provides insight into ways to make the product function more efficiently as a system.

The Economic Impact of Design for Upgradability

The environmental impact of design for upgradability is easy to see. Fewer products produced means less waste. Like many sustainable practices, design for upgradeability reveals opportunities for economic benefits as well. Design for upgradability and modularity of tangible products requires standardization of components and linkages, and offers the designer a chance to standardize parts across different product lines, maximizing economies of scale. Take back programs for used components can eliminate raw material purchases and the associated use of energy. Standardized parts can be reprocessed, recycled, or reused. With proper quality control checks, some components can go right back onto the same assembly lines as virgin parts, cutting manufacturing costs. Xerox claimed that implementation of take back programs led to a savings of over eighty million dollars in Europe in 1997. As a result Xerox was able to hire four hundred additional workers to reprocess parts and remanufacture products (Maslennikova 228).

Designing components that are durable enough to be put back into production will create inherently well-built products. Longer lasting, more reliable products have a higher perceived value, contributing higher returns at the point of sale, and further improving brand image and brand loyalty. Add to this the ability to offer upgradeable experiences and the perceived value of the product increases further.

Upgradability as a Service

Upgradability also allows the product to bridge the gap between products and services. There has been a shift in the U.S. away from a manufacturing economy into an idea economy. "The U.S. service industry is one of the major sectors in the non-good producing industries under private ownership. Approximately fifty five percent of the economic activity of the U.S. occurs in service industries (EconomyWatch). Information services are a significant part of the U.S. service industry. Information services allow for the transmission of ideas and cultural products. Service providers make the iPod possible. Without an internet service provider, iTunes, and the Apple Store, the iPod loses its functionality and appeal. The idea of "transmaterialization" may open new doors for companies seeking a sustainable business strategy. Designing intangibles can be very profitable. Selling a service as a product requires zero raw material extraction, manufacturing, or transportation costs.

The Emotional Impact of Design for Upgradability

Designing for upgradability offers many economic and environmental benefits. Another benefit that design for upgradability (and sustainable design in general) offers is emotional satisfaction on the part of the user. A user who feels that purchasing a product with better environmental performance will make a difference will derive a deep satisfaction based on the highest levels of Maslow's hierarchy of needs. This moral satisfaction provides a psychological pleasure that can lead to long lasting emotional durability. This durability will keep the perceived value of the product higher for longer periods of time, and will serve as a deterrent for replacement of said product when a replacement decision is considered.

Designing for Emotional Durability

Colin Cambell, a sociologist of consumerism, described the "mystery" of modern consumption as, "an activity which involves an apparently endless pursuit of wants, the most characteristic feature of modern consumption being this insatiability" (Slade 265). Cambell calls these reckless consumers "neophiliacs," and groups them into three categories: pristinians, trailblazing consumers, and what we might call "fashion fanatics."

Pristinians consume new products and discard old ones in order to maintain a pristine self-image. They immediately replace anything that bears the slightest sign of wear. They seem indifferent to changes in style, often buying items that are identical to the ones they replace. Pristinians are the most resistant to innovative technologies (Slade 265).

Trailblazing consumers, on the other hand, crave the newest product lines and the latest technology. These early adopters tend to make good consumers, Cambell notes, because they are the first to recognize a useful new product and play a key role in leading others to accept new technology producing a "social cascade" (Slade 265).

The third and largest group of neophiliacs are "fickle and change their preferences continuously and quickly" (Slade 266). Their sensitivity to fashion causes a very high rate of "want turnover," especially in cultural products such as music and books. "They respond with enthusiasm to almost any retail novelty that offers a new experience or sensation" (Slade 267). According to Cambell, this tendency is rare among the old, and much more common among adolescents and young adults, and, in every age group, is more prevalent in women than in men. This observation is further proof that designers should be in the business of designing "experiences" instead of focusing on designing "products."

Dieter Rams is best known for his work for the German company Braun (see Fig 7). He believes that if you analyze the functions of an object carefully enough, "you can come up with the optimum set of operating controls; you can make the perfect 'face' for a machine; you can give it a form which will outlive fashion; and you can create a truly timeless design, [that will retain value] even after the category of product has been abolished" (Rams). He developed his now famous "Ten Commandments of Design" while

Calculator Interface

Image from: http://lenovoblogs.com/designmatters/files/2008/07/iphone-calculator.jpg

Dieter Rams' work for the German electronics company Braun had a profound impact on Jonathan Ives – the head designer for Apple. The layout of the calculator interface on the iPhone was an adaptation of a calculator designed by Rams, indicating that careful design can lead to a truly "timeless design.

Fig 7

working as a professor at the School of Fine Arts in Hamburg, Germany. They are as follows:

1. Good design should be innovative.
2. Good design should make a product useful.
3. Good design is aesthetic design.
4. Good design will make a product understandable.
5. Good design is honest.
6. Good design is unobtrusive.
7. Good design is long-lived.
8. Good design is consistent in every detail.
9. Good design is environmentally friendly.
10. Good design is as little design as possible (Rams).

Designing products to be upgraded with the newest technology can make people's lives easier, but beyond the need for function in a product there is a human need for deeper connections. After the needs of functionality and usability have been met, a pleasurable experience can create a truly great product experience. It is the deepest layer of experience that can make a product truly timeless.

Emotional Durability of Upgradability

Designing products to be emotionally durable is difficult. Some timeless designs achieve this by offering an unbeatable functionality, aesthetic, or personality. KitchenAid mixers stay on kitchen countertops for decades. The product is iconic. It represents dependability, usability, and durability, as well as social status and a refined sense of taste. The Porsche 911 remains a timeless classic since its introduction in 1963, and new models have remained relatively unchanged for over forty years compared to other makes and models. In recent years the demand for the older cars has increased. While this is no doubt partly due to exemption of smog qualification on cars made prior to 1986, the increased demand for the classic 911 reinforces the idea that a strong emotional connection can keep a product viable in the face of more “modern” replacement alternatives. The experience felt by owners of this car creates a cult following and reinforces the brand promise “Porsche, there is no substitute.” These products have stood the test of time with no need for modification or updates.

Other products may retain an emotional connection with the user by updating the user experience offered by the product. The iPhone clearly attempts to establish a powerful emotional connection with its users. It is personified in the user’s manual with phrases like, “Take care not to spill any food or liquid on iPhone” (iPhone user’s manual). The writers of the manual help to create a special relationship between the phone and the user by referring to the phone as “iPhone,” rather than “*the* iPhone”. The buyer of an iPhone can also “name” their phone, giving it an identity that is recognized by other devices. This along with a sophisticated aesthetic, as well as a high level of intuitive functionality, gives the iPhone its own personality. Most iPhone owners seem to feel a special connection with their phones unlike any other mobile device. Apple seems to have succeeded in establishing that connection.

However, the iPhone suffers from a kind of planned obsolescence. Apple employs psychological obsolescence with the introduction of "new models." When a faster service becomes available, such as 4G, the solution offered from Apple is to buy a new phone, instead of replacing a single module. The battery will eventually die (no doubt sooner than later), and the phone will be useless without delicate surgery. Without the ability to easily replace the battery, the phone will most likely go into a landfill. Glass screens are delicate and require factory replacement. The reality is that these new models are little changed from previous models and offer almost exactly the same functionality and usability, with more speed and accuracy.

Experiences can be renewed by offering upgrades or updates in technology that allow the product to perform new functions. When a new function becomes available for an old product, a new experience is born. This keeps the user occupied and prevents boredom. This can be achieved by updatable modules or new software

Customization and style upgrades allow the user to change the product to meet changes in lifestyle, or to match current fashion trends. Keeping up with changes in clothing fashion trends is a never-ending challenge, as they change seasonally. This is especially true of people who like to accessorize, particularly women. This means that products that are carried out of the home, such as a cell phone, or worn, such as a wristwatch, must be able to adapt instantly to meet different style preferences. While products that remain in the home, such as a lamp or a kitchen appliance, can go for longer periods of time without change.

Design for Simplicity

"We ascribe beauty to that which is simple; which has no superfluous parts; which exactly answers its end; which stands related to all things; which is the mean of many extremes."

-- Ralph Waldo Emerson, The Conduct of Life, "Beauty" (1860).

Somewhere in our minds we have the idea that simple is better, but why is that? The argument about design for simplicity usually focuses on the aesthetic and functional benefits. Simple, elegant designs are more aesthetically pleasing, and are easier to use than complicated ones. In the early 1990's, two Japanese researchers, Masaaki Kurosu and Kaori Kashimura, studied different layouts of controls for automatic teller machines (ATM). All versions of the machines were identical in function, the number of buttons, and how they operated, but some had the buttons and screens arranged attractively, the others unattractively. The researchers found that the attractive ones were perceived to be easier to use. Noam Tractinsky, an Israeli scientist attributed this result to the aesthetic culture of Japan, and decided to repeat the experiment in Israel, a culture which he deemed to be more "action-oriented." To his extreme surprise, the results were stronger in Israel than in Japan (Norman 17).

The less visual "clutter" a product has, the less the user is forced to absorb in a short time period. When given fewer options, the correct option becomes clearer, this, in turn, allows users to perform tasks with more efficiency. When given too many options, the user's mood turns to that of apprehension and frustration. This causes the user's vision to narrow, and problem solving ability is diminished. This is a useful strategy in escaping danger, but not in thinking of imaginative new approaches to a problem (Norman 19). Today, users expect more instant satisfaction. With attention spans growing shorter and shorter the importance of design for simplicity is becoming more and more important. However, style and functionality are not the only benefits of a simple design. Simple is honest, practical, and beautiful, but simple can also be green.

The more complicated a product becomes, the more components it needs to facilitate the added intricacy. A product with more components takes more time to design, and more energy and raw materials to produce it. It also contains more material to be disposed of at the end of the product's life span. Design for simplicity eliminates some of the time it takes to design and engineer a product, some of the energy required to produce the product, and some of the waste created when the product is discarded. It is important to reduce the number of functions a product has to a minimum – leaving only what is necessary.

This is a great opportunity for designers to consider how a service might offer the same benefit as a piece of hardware. One memory chip and one processor can potentially allow a product to perform many functions. The software that is developed is sold like a product, but is delivered through a service. As memory and processing modules get smaller and more powerful, the product can remain viable with minimal components used in the design.

Design for simplicity is a common topic for interface designers, but it is less common among product design circles. There are several methods and guidelines for integrating simplicity into product designs.

Design for Modularity

Design for modularity enables simple products to replace more intricate ones by allowing the user to upgrade existing modules (or to add functions if the product is “too simple”) to meet changing needs. In doing so, they have a more active role in the “designing” of the product, which should increase the emotional connection the user shares with the product.

When designing for modularity, it is important to use system design thinking. Examine the module itself and its life cycle, as well as any other components, packaging, infrastructures, and biological systems that the module will affect. It is important to understand the product’s limitations thorough analysis of its technological, fashion, and mechanical life expectations. Some modules will be designed for durability, such as a main structural component, while others will be designed to be more “disposable.”

Technological obsolescence is less likely if the technology relies upon a heavily invested infrastructure. Example: Ethernet (and wireless Ethernet) will probably remain the network connection of choice due to the fact that every home and business installs it, so its limiting factor will likely be fatigue, as it is hidden from the user.

Seemingly unchangeable infrastructures exist. This can be a good thing because it standardizes parts and increases efficiency, but it can also be bad if we become reliant on it. Oil is a good example. The vast array of uses means oil is – at the moment – a vital and necessary part of our lives. Whether it is extracted from the Earth’s crust, or soybeans, it is an unsustainable resource. This is why it is so important to approach every problem, no matter how big or small, with design thinking.

Responsibility of Designers

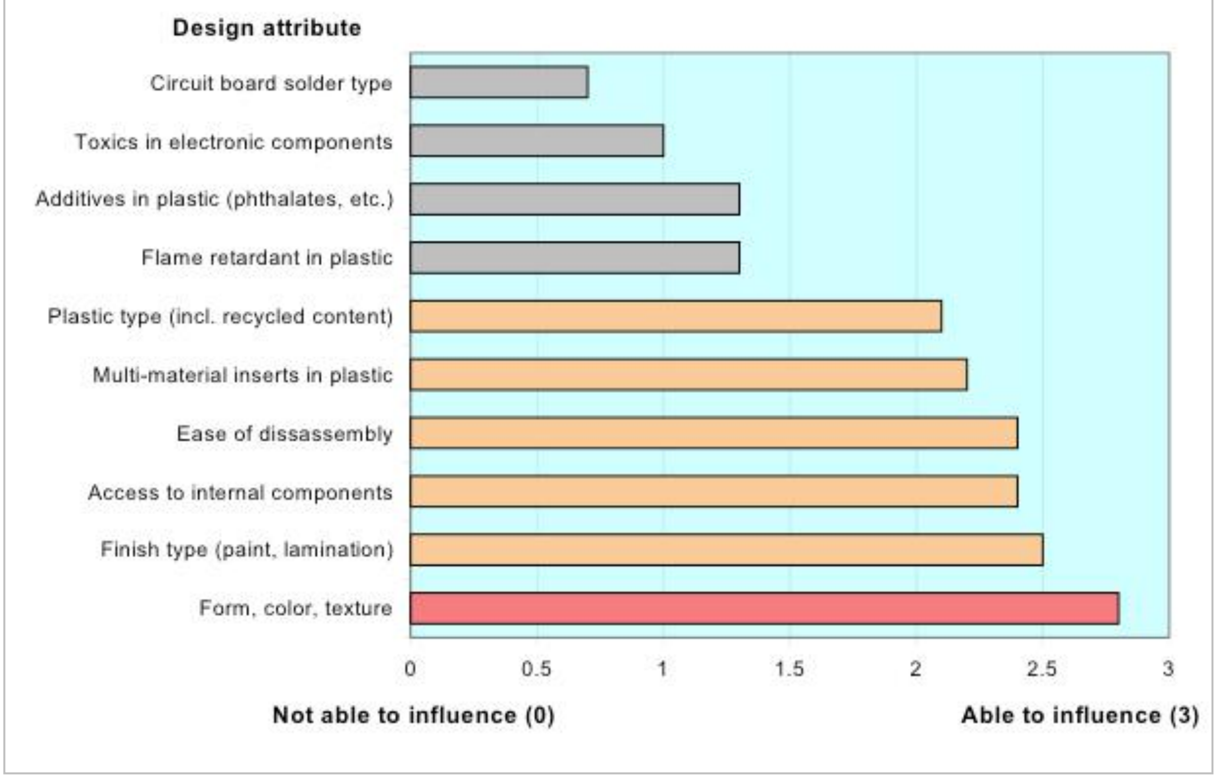
This is a critical time. We are at a crossroads. Humans can choose to try to undo the damage that we have done to the planet, or ignore the problem and hope that it works out in the end. Given that the problems appear to getting exponentially worse, ignoring the problem will undoubtedly lead to irreversible damage. The sooner we choose to address the problems that are a result of our materialistic culture, the easier it will be to affect them. Most people feel that there is little they can do to combat the global crisis (though some still choose to do all they can). Yet, designers are in a unique position to influence many of the impacts that the product industry has on the environment.

As designers, we should ask ourselves: What are the impacts of the product design industry? What criteria do we currently use to measure the value of a successful product design? Is superior environmental performance part of the criteria? Should design for reduced environmental impacts be our responsibility or someone else's? If ours, why? If someone else's, whose and why?

It is obvious that *money* is the current criteria by which we measure the success of a product, and environmental impact is, at best, a minor consideration. However, the irony of this is that sustainable practices are often beneficial to the bottom line, saving the company money as a result of careful planning and waste reduction. As far as whose responsibility it is to make products more Earth-friendly, the duty should be shared among upper management, designers, engineers, and the end consumer (whose buying patterns influence management's decision on which products will ultimately be produced). Designers are in a unique position to influence the impact that a product will have over its entire life cycle through careful design, and to convince the upper management that sustainable practices are good for the organization.

In a May 2003 survey of product designers conducted by the Silicon Valley Toxins Coalition and the Industrial Designer Society of America (the IDSA), members of the IDSA Eco-Design section and the IDSA Electronic Product group (fifty two respondents) were questioned to measure the level of understanding and influence that product designers have about the environmental issues of the products that they design (IDSA).

Fig 8: **Ability of designers to influence design attributes**
(averaged values)



The survey showed that environmental impact was the lowest priority of all of the product qualities in question. This indicates how poorly environmental performance of products is integrated into the product development process. The same survey showed that designers feel they have more ability to influence certain design attributes than others. Aesthetic and touch points are among the attributes that designers feel they have influence over. Designers felt that engineering decisions, such as types of electronic components and plastics, were out of the designer’s hands. The survey also shows the dominance of economic information in influencing clients and management of the benefits of environmentally friendly attributes (IDSA).

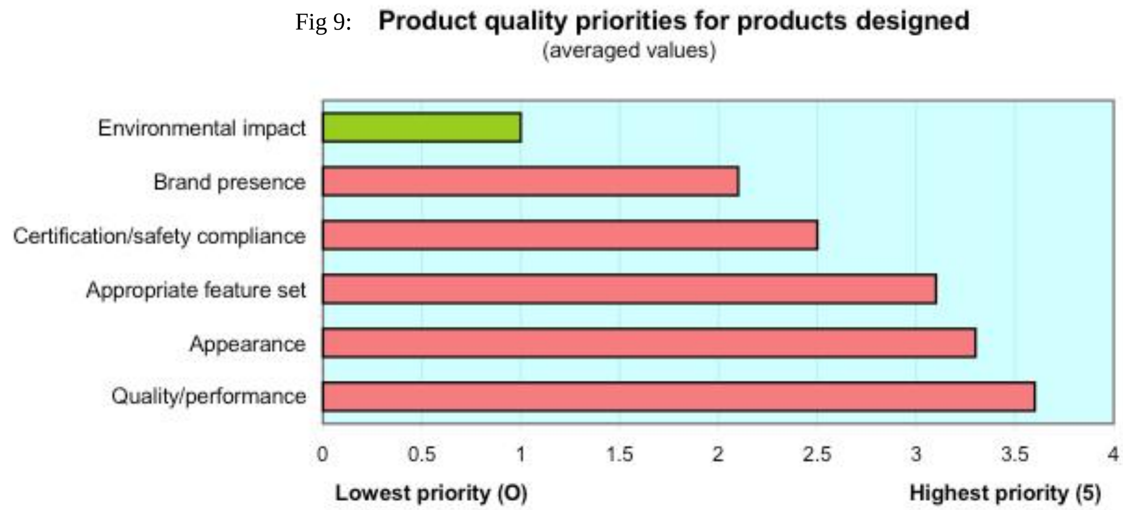


Fig 9:

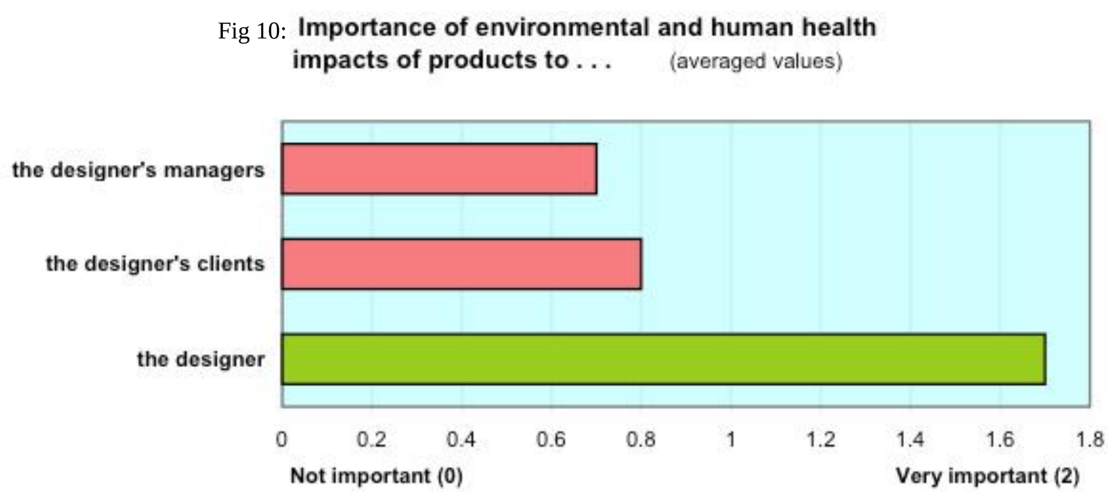


Fig 10:

Understanding the impact of each of the phases of the product (and individual component) life cycle is necessary to produce the most sustainable solution. Proper lifecycle assessment (LCA) is an important foundation for anyone who is interested in eliminating waste in production. The IDSA advocates the Okala Guide as a starting point for designing products that minimize damage to and restore the health of our natural environment. The Okala Guide 2007 suggests simple models and methods of assessing the lifecycle of products and the impact that the product has on the planet.

Designers must consider sustainability as a design constraint from the earliest stages of the design process. Design solutions to the problem of waste production include, on one hand, designing components that will have less impact on the planet at the end of life phase (i.e. to be less durable) and, on the other hand, product life spans can be increased to more closely match their durability. Design for disassembly makes it possible to separate product materials for recycling, reuse, or biodegradation. Biodegradability will undoubtedly reduce the amount of material that ends up in landfills, and the material that does make it to the landfill will biodegrade faster. Biodegradable materials can be used to compost, assuming another useful role for the material after it is discarded. Recyclability means that the cost and waste that accompany raw material extraction and processing (or production in the case of biomaterials) are reduced. However, the transportation and manufacture of these recycled materials into products, and the distribution and sale of these products and their packaging, are not addressed by recycling, reusing, or composting used materials. Recyclable, reusable and biodegradable materials are beneficial, but the most sustainable product (or material) is the one that never has to be produced in the first place.

Making products last longer solves many of these problems. Making the product last for a longer period of time leads to fewer products being produced to satisfy demand. Designers must consider design for take-back, reuse, secondary roles, and transmaterialization. Components that can be reclaimed can be put back into production, reducing materials and energy used to produce new products.

Anticipating changes in technology, as well as changes in user’s attitudes, is crucial for designing products that can be updated to meet changing criteria. Designers (especially in the electronics industry) must make products that are modular, upgradable, and emotionally durable. They must stay educated on developments in greener materials and processes. Finally, and most importantly, they must understand the needs of the user, and anticipate changes in attitudes that are likely to occur during the lifetime of the product.

As mentioned earlier, upper management is likely to put a low priority on environmental performance, so it is up to concerned parties (such as environmentally responsible shareholders and product designers, as well as customers that a company's products) to show upper management that environmental performance is important. As design managers bridge the gap between design, marketing, and engineering, as well as the users, they are in an exceptional position to influence the engineers, upper management, and marketing to all make more responsible decisions. There are several points for arguing for sustainable practices in design.

Companies that employ design for sustainability find that it:

1. Reduces the environmental impact of their products/processes
2. Optimizes raw material consumption and energy use
3. Improves waste management/pollution prevention systems
4. Encourages good design and drives innovation
5. Cuts cost
6. Meets user needs and wants by exceeding current expectations for price, performance, and quality
7. Increases product marketability
8. Improves organization's image (Bahmra 28)

Marketing departments should take less convincing than other members of an organization. At least seventy seven percent of consumers polled from the United States, the

United Kingdom, China, Brazil, India, Germany, and France claim that they favor a product with tangible environmental advantages over competitive products (WPP). However, marketing professionals are trained to obey the numbers, and tend to base decisions based on what has worked in the past. It is a good idea when addressing marketing and upper management to have some industry research and cost analysis prepared, and defend your argument with hard data. Sustainability is about much more than helping the environment, it is about sustaining a profitable organization.

Engineers probably have less control over changes to the product's environmental impact than do designers. They are charged with making components that will live up to the brand promise of the company, and are bound in most cases to the types of tooling and infrastructure that exists within the corporation. Changes in tooling or manufacturing process of a product require the most risk, as these changes are extremely expensive. Engineers must be kept aware of innovative changes in materials and processes in order to make manufacturing more sustainable and efficient.

Responsibility of Consumers

While the consumer does not have any input into the materials and manufacturing processes of the products that they buy, they do control the types of products that will be produced in the future. When consumers send a clear message to manufacturers that they will buy more environmentally friendly products over the alternative, manufacturers will be forced to produce products, and change to industry practices with better environmental performance.

There is a "fast-food" attitude in this country – one of excess materialism. People act concerned about the environment, but do very little or nothing to change their behaviors on a large enough scale to combat the damage that they do. People may buy one product over another because it claims to be more environmentally friendly, but most do not care, or do not understand what these claims actually mean in the grand scheme of things. In a deceptive use of green marketing, some products are "greenwashed" (a term used to describe the practice of companies disingenuously spinning their products and policies as environmentally friendly). For example, many people may think that plastic bags are more harmful than paper ones, because they take so much longer to decompose in a landfill. The truth is that the production of plastic bags needs just a small fraction of the energy required to produce paper ones, and plastic bags are just as recyclable. One must weigh whether it is better to use less energy and produce less waste during production, or produce a product that will be more manageable when discarded. The ultimate objective of the product designer is to provide the consumer with products that accomplish both of these goals.

It is up to the consumer to educate his or herself on the effects that the products they buy have on the environment. As discussed earlier, the environmental performance of their products is of little importance to manufacturers, and as a result, is usually very poor. It stands to reason that the consumer will receive no such education from the manufacturing industry, or from the advertising that has such an influence on product purchase decisions. Instead, the consumers must make an effort to seek information on the effects of the products they buy on their own.

The good news is that there are a growing number of resources available to show consumers how to make better informed decisions. The increased publication of reference materials for sustainability means that the information is there for anyone who cares enough to look for it. Websites such as Treehugger.com make information on sustainability easily available for anyone with internet access.

Customers must learn not only about the damaging effects that certain materials and manufacturing processes have, but also the more obscured causes, such as raw material extraction, transportation and energy and water usage. Customers must learn the importance of looking at the entire life cycle of products that they are considering purchasing. The total energy used from extraction and processing of materials to the end of life phase may have more damaging effects than the material itself.

In her short film “The Story of Stuff” Ann Leonard highlights the “hidden” effects of the product industry. She diagrams the impacts of the different phases of product life cycles from extraction to disposal, and the effects that this process has on humanity. For example, impacts on the people who live and work in the areas that our raw materials come from are frequently overlooked in discussions about sustainable design. She stresses the importance of changing the linear system of production into a closed loop process to produce a “cradle to cradle” model in place of the more traditional “cradle to grave” model.

Consumers should also understand obsolescence as an invention to manipulate them into repetitive buying in order to deliver a company’s products to the greatest number of people and spread prosperity within the organization, at the expense of quality of life for all.

Responsibility of Lawmakers

Yet more responsibility lies with the government agencies charged with regulating pollution, energy use, and the use of harmful materials. They must continue to enforce more stringent protocols involving sustainability, and provide consumers with the information they need to make more educated decisions about which products to buy. In much the same way the Food and Drug Administration (FDA) requires nutritional information labels and lists of ingredients on packaging for the food we buy, the Environmental Protection Agency (EPA) could require a label on the packaging of products showing the carbon footprint, LCA, and/or the list of materials used in the product. This simple label would allow consumers to compare products side by side before making purchase decisions.

CHAPTER 5: DEVELOPING A DESIGN APPROACH

This chapter will present a number of design methods and strategies aimed at producing products with a high level of upgradability and emotional durability. This durability will result in a desire to retain and use the product for longer periods, thus producing a more sustainable design solution. These methods are to be used in conjunction with traditional design methods (such as sketching and brainstorming), as well as the "cradle to cradle" philosophy and the Okala life cycle assessment methods.

Cradle to Cradle: Five Steps to Putting Eco-Effectiveness into Action

Step 1: Get free of known culprits.

Avoid limiting your focus to the most obvious harmful materials. Although eliminating known harmful materials is crucial, doing so might passively allow another, "less harmful" material to infiltrate the product. Even these "less dangerous" materials can accumulate over time in the downcycling process. Actively choosing safe materials is the ultimate goal.

Step 2: Follow informed personal preferences.

Most of the long-term effects of the materials that make up the products we use are largely unknown. What little we do know does not look good, as "most of the products we [the authors] have analyzed do not meet truly eco-effective design criteria" (McDonough 169). When confronted with two choices that are less than ideal, there are a few guiding principles that can help. Prefer choices that opt for *ecological intelligence*, *respect*, and *delight, celebration*, and *fun*. Avoid products that are blatantly harmful for human health or the environment, and thoroughly research available choices. Show respect for the people who live or work in or around locations where materials are extracted, refined, manufactured, and disposed of. Provide products that express the best in design creativity, adding pleasure and delight to life. "It is very important that ecologically intelligent designs be at the forefront of human expression," rather than relying on guilt to influence an immediate decision (McDonough 173).

Step 3: Create a passive positive list.

X-List	Gray List	P-List
Asbestos	Ammonia	Recyclable Plastics
Formaldehyde	Chlorine	Aluminum
Benzene	Phosphates	Stainless Steel
Antimony Trioxide	Petroleum Distillates	Wood
Chromium	Polycarboxylates	Leather
Lead	Non-Recyclable Plastics	
Mercury	Arsenic	
Brominated Flame Retardants (BFR's)	Poly Vinyl Chloride	
Cadmium		

Passive Positive List

Table 1

Conduct an inventory of the entire palette of materials that comprise a product, and the substances it might give off during its lifetime, manufacturing, and disposal. Screen them based on a series of environmentally oriented questions. Once screened, place materials on one of three lists to assign a level of urgency to problematic substances (see Table 1). This "technical triage" contains an *X-List* for materials that are the most harmful to human health or the biological system, a *Gray List* for materials that are in less need of immediate phase-out, and a *P-List* (or *positive list*) for materials that are known to be less harmful or beneficial. Knowledge of these materials will be increasingly crucial for product designers hoping to stay ahead of the pack when it comes to producing healthy products, as enforcement of the Environmental Protection Agency's Toxic Substance Control Act (TCSA) becomes more aggressive in response to world-wide reform – particularly in Europe and China.

Materials should be evaluated based on:

- Acute oral or inhalitive toxicity
- Chronic toxicity
- Whether the substance is a strong sensitizer
- Whether the substance is known or suspected to be bio-accumulative
- Toxicity to water organisms (fish, daphnia, algae, bacteria, etc.) or soil organisms
- Biodegradability
- Potential for ozone layer depletion
- Whether all by-products meet the same criteria

Step 4: Activate the positive list

Here is where the eco-efficient redesign process begins in earnest, where we can stop being less bad and attempt to do more good. By using only approved materials the product can be designed from the beginning to be part of the technological or biological nutrient cycle. This step allows for vast improvements on current paradigms. Using materials that do not require paint or permanent bonding can eliminate problems in virtually every step in a product's lifespan.

Step 5: Reinvent

This step involves re-examining the problem that the design will serve to address, as well as looking at the entire technological and biological systems of which the product will be a permanent part. By asking the correct questions (What is the consumer's need, how is the culture evolving, how can these needs be met by appealing and different kinds of products or services?) new and original opportunities can emerge.

Okala

The Okala handbook outlines seven areas in which to explore opportunities to create more environmentally friendly products. These areas are diagramed in the “Ecodesign Strategy Wheel” (see Fig 11). They are:

1. Design for innovation.

    • Rethink how to provide the benefit.

    • Provide needs provided by associated products.

    • Anticipate technological change and build in flexibility.

    • Design to mimic nature.

    • Use living organisms in product.

2. Design for low-impact materials.

    • Avoid materials that damage human health, ecological health, or depletion of resources.

    • Use minimal materials.

    • Use renewable resources.

• Use waste byproducts.

• Use thoroughly tested materials.

• Use recycled or reused materials.

3. Design for Optimized manufacturing.

• Design for ease of production quality.

• Minimize manufacturing waste.

• Minimize energy in production.

• Minimize number of production operations.

• Minimize number of components/materials.

Okala Eco-Design Wheel

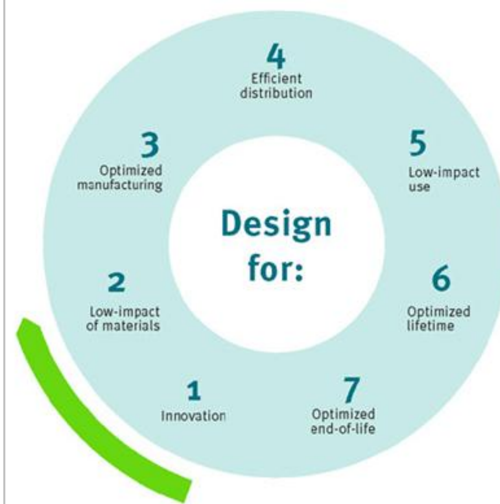


Image from: Okala Design Guide 2007

The Okala Eco-Design Wheel outlines seven steps toward implementing sustainable design during the product design process.

Fig 11

4. Design for efficient distribution.

• Reduce product and packaging weight.

• Use reusable or recyclable packaging.

• Use an efficient transport system.

• Use local production and assembly.

5. Design for low-impact use.

• Minimize emissions/integrate cleaner or renewable energy sources.

• Reduce energy inefficiencies.

- Reduce water use inefficiencies.
- Reduce material use inefficiencies.

6. Design for optimized product lifetime.
    - Build in user’s desire to care for product long term.
    - Design for ease of product take-back programs.
    - Build in durability.
    - Design for maintenance and easy repair.
    - Design for upgrades.
    - Design for second life with different function.
    - Create timeless look or fashion.
7. Design for optimized end-of-life.
    - Integrate methods for product collection.
    - Provide for ease of disassembly.
    - Design for recycling.
    - Design for reuse, or “next life of product”.
    - Provide for reuse of components.
    - Provide ability to biodegrade.

• Provide for safe disposal (34-39).

The main focus of this study has been on optimized lifetime through innovation, and the establishment of a strong emotional connection with the user, as well as implementation of creative design for end-of-life. In so doing, the design methods laid out in this chapter will affect all of the stages of product life discussed in the Okala Eco-design Wheel.

Method 1: Component Life Chart

The goal of the Component Life Chart is to group all of the components of a given design into just a few manageable groups (three or four at the most) that can be replaced with the same module, or during the same maintenance event, and to identify opportunities to innovate in the earliest stages of the design process. This method should be used to identify components that do not meet the correct criteria for durability or longevity.

Basic Steps

Step 1: Make a list of all of the components that will make up the product.

Step 2: Identify the expected lifespan of each component based on fatigue, changes in technology, and changes in fashion.

Step 3: Group the components based on dependencies and lifespans.

Considerations: Pay special attention to parts that tend to fatigue long before or long after other related components, as these will lead to premature replacement or disposal of fully functioning mechanisms.

Explanation

Make a list of all of the components that make up the overall design. This list should include main constituents, such as circuit boards, structural components, etc. It is not necessary to break down components such as these into smaller and smaller constituents, as the goal is to reduce the number of groups. However, there is an opportunity in this step to identify "sub-components" that will prematurely retire a module before it has reached its fatigue or fashion limits (more on this to come).

It is necessary to obtain some research into the lifespan of each component based on fatigue, as well as changes in technology, or fashion. Design components with similar lifespans to fit into the same module whenever possible. Start with basic components, then break up those components into subcomponents and evaluate whether or not subcomponents can be placed into other groups, or made more accessible. Color can be a great way of differentiating between groups of color.

Component	Anticipated Fashion Life	Anticipated Technological Life	Anticipated Fatigue Life	Notes
1 Component 1	N/A	5 yrs	50+ yrs	Opportunity to use biodegradable or highly recyclable material
2 Component 2	3 yrs	10 yrs	2 yrs	Need to make component more durable
3 Component 3	N/A	10 yrs	5 yrs	Need to make component more durable
4 Component 4	N/A	5 yrs	10 yrs	Opportunity build in updateable subcomponent to increase tech life
5 Component 5	3 yrs	5 yrs	50+ yrs	Attempt to use methods to increase fasion life to minimun of 5 yrs. Opportunity to use biodegradable or highly recyclable material

Component Life Chart

Table 2

Identify the expected lifespan of each component based on fatigue, changes in technology, and changes in fashion. Produce a chart with four columns (see Table 2). The first column contains rows for components to be evaluated. The second column is the estimated “fashion life.” This number is the time it takes for the aesthetic value of the component to diminish to the point where the user decides to replace it. The third column is the estimated technological lifespan of the component. This number is dictated by anticipated technological advances and emergent technologies. The fourth column contains the estimated lifespan of the component based on fatigue caused by normal use of the component. The lowest of the numbers in each row determines the expected lifespan of the component (illustrated here in green). The final column contains notes on possible opportunities to innovate, or suggestions on where to implement more or less durable materials to increase or decrease component lifespans. It may be helpful to make use of color in order to quickly identify component groups based on expected life.

Group the components based on dependencies and lifespans. Notice how some components have very long fatigue life and a very short technology life. These components of the design can be engineered with less durability, with more consideration given to optimizing the end of life phase of the component life cycle. Designers should address the issue of the eventual disposal or recovery of each component of a design, and suggest ways that the manufacturer can implement strategies to recover them. Conversely, some components will have very long technology lives and short fatigue lives. These components should be made more durable, with more emphasis on low-impact use and optimized lifetime.

By employing this method the designer can see at a glance which aspect of the component is limiting the lifespan, and, as a result, can group the components logically into modules which can be replaced to prolong the usable lifespan on the product, as well suggest to the engineers how to optimize the lifetime of each component.

Method 2: Component Relationship Wheel

This method will clearly illustrate the relationship of different components based on the life expectancy and dependencies of each component. The goal of this method is to assemble different components together into main modules so that they can be easily replaced during the same maintenance event. This method is appropriate when it is required to identify the physically-, and functionally-dependent relationships between components.

Component Relationship Wheel

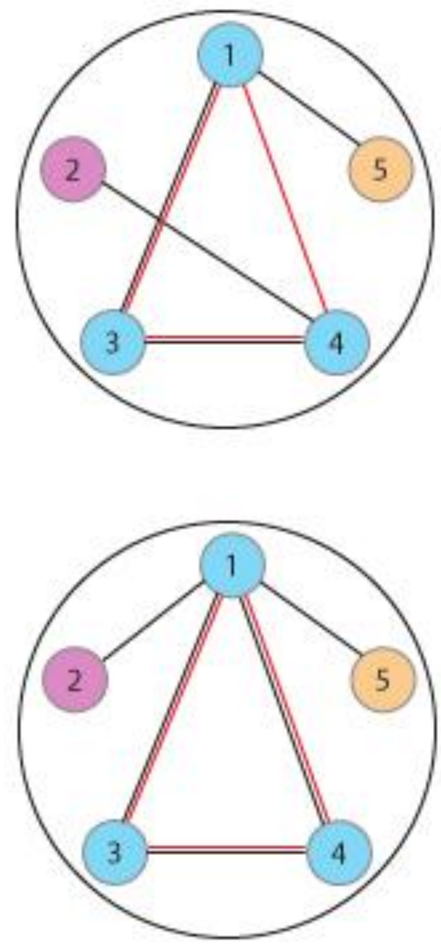


Fig 12

Basic Steps

Step 1: Arrange the list of components of the product in a circle.

Step 2: Draw a black line between components that share a physical connection.

Step 3: Draw lines of a different color between components that are related by anticipated lifespan.

Step 4: Attempt to match the colored lines with the black lines as often as possible.

Considerations: Explore as many variations as possible.

Explanation: Steps one through three need little explanation (see Fig 12). Refer to information attained from the component life chart to assist with step three.

Attempt to match the colored lines with the black lines whenever possible. The lines between the components indicate which components will make up each module. Several combinations of components are possible, so several wheels will be generated to show different possible outcomes. The best outcome will be the one explored in the sketch phase.

Method 3: Hypothetical Timeline

A hypothetical timeline will help the designer to explore possible replacement schedules for product modules, as well as illustrate to the client the value of modular product development. This exploration should give the designer a better idea of which modules will be replaced more often than others, and how many times they are likely to be replaced. Using information gained from the component life chart and component relationship wheel, the designer can begin to contemplate how the modules will be replaced, how they will connect to one another, and how to responsibly handle the components after the user is finished with them. It will aid in decisions regarding ease of replacement (types of fasteners, etc.), needed changes in placement of components, and optimizing the lifespan, end of life, and material make-up of the components (implementing take-back programs, for example.)

It is not necessary to produce precise product sketches or renderings during this method, as it is an exploration of module replacement, rather than an exploration of product architecture. The hypothetical timeline should be done in conjunction with exploratory product sketching to provide direction for the development of the product architecture.

Basic Steps

Step 1: Illustrate a simple exploded or ghosted view of the product as it will be purchased.

Step 2: Illustrate a simple exploded view of the product after the first module replacement event.

Step 3: Illustrate a simple exploded view of the product after the second module replacement event.

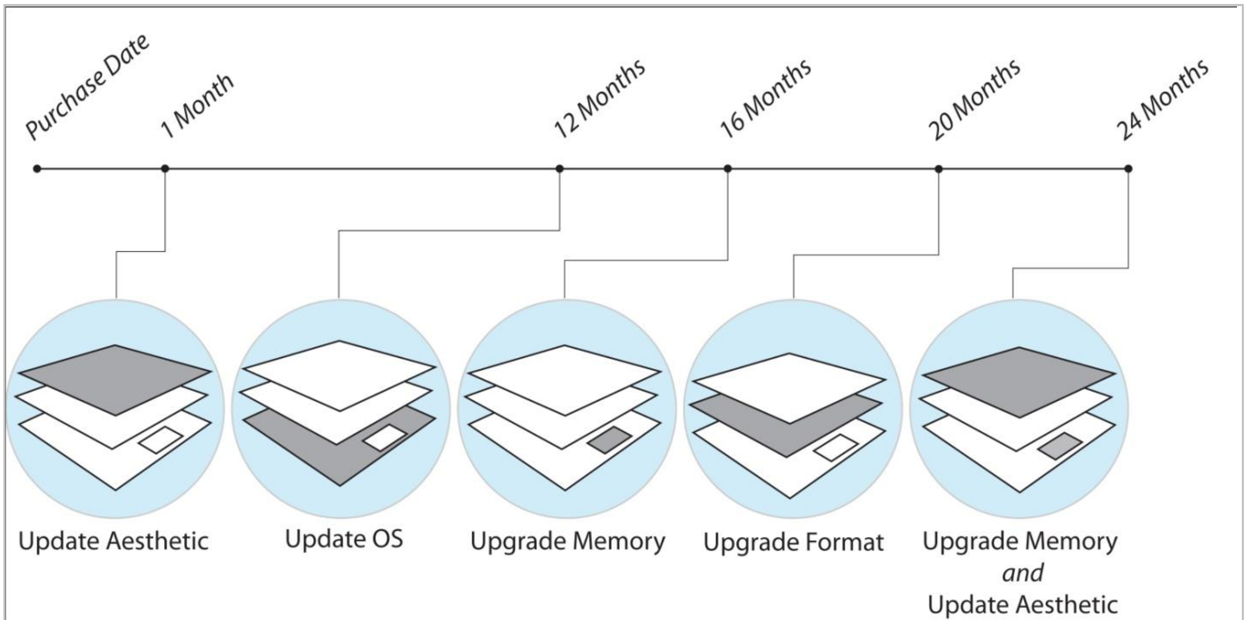
Step 4: illustrate a simple exploded view of the product after the third module replacement event.

Considerations: To save time, the exploded views used in this method can represent modules with simple geometric shapes, rather than realistic depictions. This is a good opportunity to explore how the user will access the different modules for replacement.

Explanation: Illustrate a simple exploded view of the product as it will be purchased. This view shows the product in its original configuration (see Fig 13). It may be useful to color code the different modules for easier identification.

Illustrate a simple exploded view of the product after the first, second, and third module replacement event. Information from the component life chart can help to identify which modules will be replaced during each maintenance event.

After the exploded views have been generated, it should become more clear which modules will need more accessibility, as well as the type of fasteners used to connect the modules. Modules that are replaced more frequently will need to be designed with easy replacement in mind. Components that will last through multiple disconnections must use fasteners that will not wear out and break after repeated replacements. Snap-fit fasteners for replacement without the need for tools are less durable, and more likely to break after repeated use. Simple screws can be removed and replaced several times without stripping the threads. Threaded metal inserts will add durability, but can result in the component being unfit for recycling.



Hypothetical Timeline

Fig 13

Method 4: Combining Service and Product Design

This method is aimed at dematerialization or transmaterialization of an incumbent product. Dematerialization can be defined as getting rid of as many unnecessary parts as possible to create a product that uses less material. Transmaterialization can be defined as: allowing the benefit offered by a product to be offered by a service, changing the product from tangible to intangible. These two processes will eliminate the amount of technical mass that must be responsibly reclaimed at the end of the product's useful lifespan.

Basic Steps:

Step 1: Rethink the benefit.

Step 2: Produce a Venn diagram to re-examine the system as a whole.

Step 3: Use color to identify aspects of product that can be substituted with service design.

Step 4: Offer the benefit using as little of the product as possible.

Considerations: It is important that this method be considered in the first stages of the design process, as it will determine what components will physically make up the product.

Explanation:

Rethink the benefit of the product. This should be the first step of any design process. Before you can solve a problem, you first must understand the problem you are trying to solve. Attempt to break the problem down into its most basic form. Example: instead of asking "how can we design a better cell phone?" ask "how can we design a better mobile communication device?" The outcome from the first question will provide another cell phone, but asking the second question could lead to the creation of a new category of product.

Venn Diagram for a Flashlight

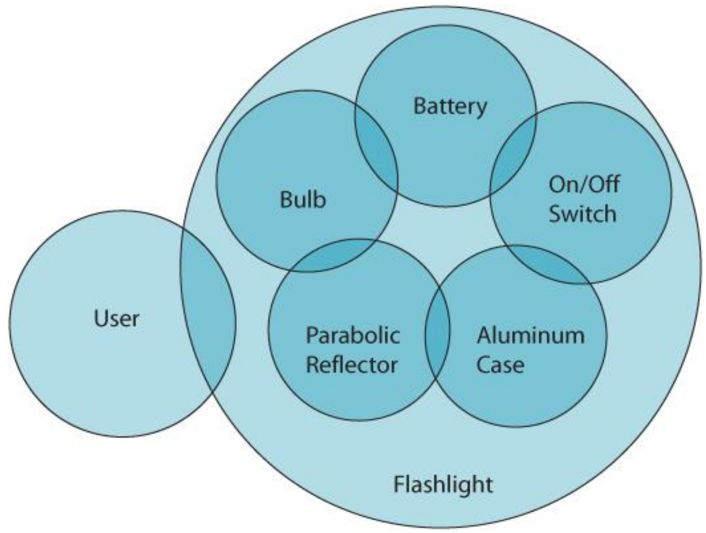


Fig 14

Re-examine the system as a whole. Systems design methods include creating Venn diagrams, interaction matrices, etc. Creating Venn diagrams makes it possible to examine systems and subsystems and their interactions at a glance. The designer can take this examination as far as is needed for the specific project at hand.

Venn Diagram for a Mobile Phone

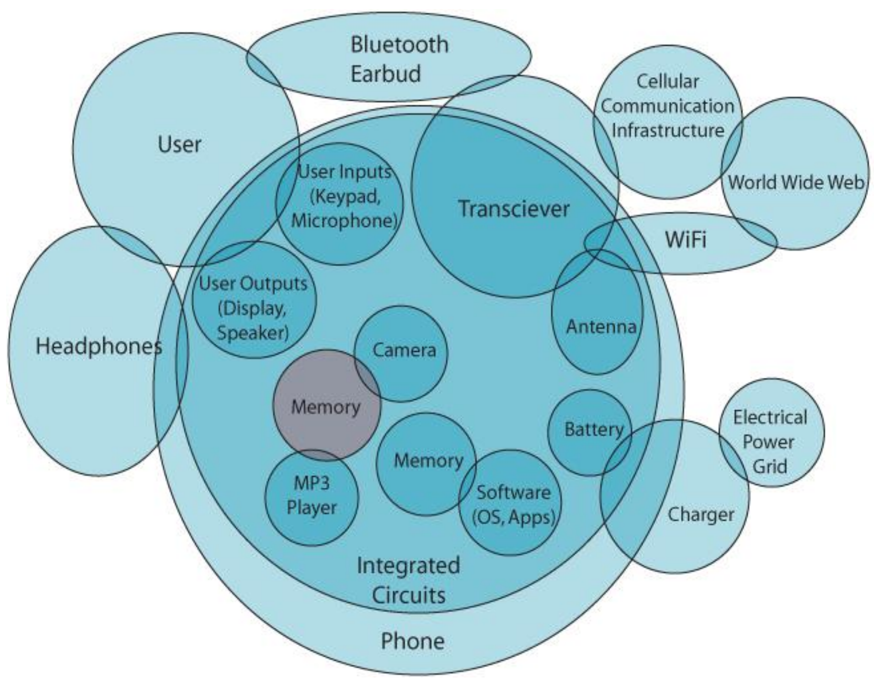


Fig 15

Examining the systems involved in designing a mobile communication device, for example, will require a more in-depth examination than a flashlight (see Figures 14 and 15).

Use color to quickly identify aspects of the product that can be replaced with service design (see Fig 12). Memory in a software oriented electronic device, for example, could be replaced with cloud storage. This means that the function that would normally require an internal memory chip and associated parts, energy use, etc. is not necessary to facilitate that function. Instead, an existing server can be used to store information for clients, and can then be used to provide a different benefit at a later date. This is an example of transmaterialization of a piece of hardware to a service or reprogrammable software.

Offer the benefit using as little of the product as possible. Identify opportunities for transmaterialization and de-materialization. The object of this step is to eliminate as many of the components of a product that are not necessary to deliver the functionality that is expected by the user.

Emotional Modularity

This is arguably the most important aspect of creating a product with an optimized lifetime. No matter how durable, clever, modular, or easy to use the product may be, if a consumer grows bored with it, they will be very likely to replace it. However, items that hold a high emotional or sentimental value for the user will be harder for them to replace, and will most likely be used longer, even finding secondary uses after the primary intended function has been taken over by a new product. Being able to update the user's experience through form, color, usability, etc. will renew the pleasure offered by the product, greatly extending the product's lifetime. If a new function is available every six months, then the users are renewing their connection with the product every six months, and the product

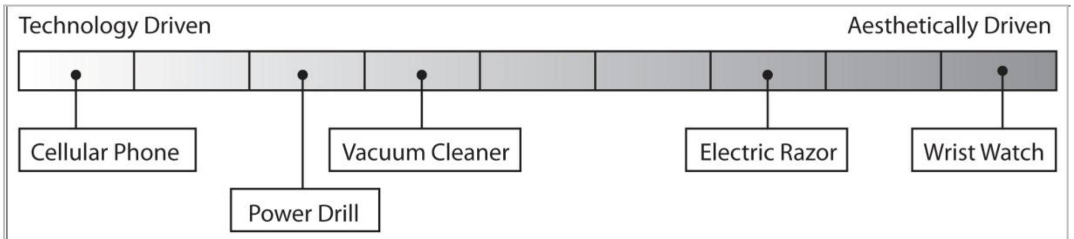
Most people can be trained to be skilled designers – for example, learning how to use space, lines, balance, shape, form, color, proportion, texture, and value. Designers can use the Golden Ratio and root rectangles to establish proportion. There are methods available for designing products with high emotional value. However, only a handful of designers have the natural talent to create truly timeless designs. Because not all designers possess the perfect vision of Dieter Rams or Jonathon Ive necessary to create timeless aesthetic, they must find ways that they can design products with long lasting emotional attachment. One way that a designer can design a product that can anticipate any changes in fashion or taste, is to design the product with modular aesthetic. This, in addition to a pleasurable interface, should ensure that the product will retain its emotional value for decades. *Designing Pleasurable Products*, written by Patrick W. Jordan, discusses in detail several of these methods for designing products that have high emotional value.

Opportunities to update a product's emotional connection with the user include:

1. Modular aesthetic
2. Modular interface
3. Modular functionality

Method 5: Implementation of Modular Aesthetic

Place the product on a sliding scale based on how aesthetically driven. Products that are more technocentric will require more easily-changed aesthetic (see Fig 15), because these products rely heavily on modern looks and the “wow” factor. This means that the consumer must have easier access to replacing the look to make it look more modern. Products that emphasize more aesthetic appeal (such as the Dirt Devil Cone, or “status symbol objects”) rely heavily on the aesthetic design to appeal to a potential buyer, and are likely to remain aesthetically pleasing to the user for longer periods. These need to have more time spent on the aesthetic during the initial design phase, and need less attention paid to replacing the aesthetic.



Technology-Aesthetics Scale

Fig 15

Conducting participant questionnaires or interviews, immersion of the designer into the user-product interaction, as well as focus groups and co-discovery events can aid the designer in assessing the importance of maintaining a new aesthetic for a particular product type. It may be a good idea to ask consumers about a wide variety of products, and not just the project being worked on. This information can be used later on other projects, and can help to clarify discrepancies in individual taste, etc.

Method 6: Implementation of Modular Interface

When designing for a modular interface, the designer must consider the user's input and output device, as well as the system that the user is attempting to control. Some user input platforms (such as the touch screen on the iPhone) are extremely versatile. They require no change in hardware to facilitate new functionality, or new "themes." The high resolution touch screen on the iPhone also serves as a very adaptable output device. User inputs and outputs such as these are more accepting of changes in interface software. A button-oriented interface – if designed carefully – can also continue to offer the needed functionality of a less complex product as the product's interface changes. A simple directional button pad, for example, combined with non-specific buttons (such as buttons that use color to differentiate themselves) can accomplish a variety of tasks – both intended and unforeseen. When designing game console controllers, designers use labels such as "✕, ○, △, and □" or ", , , and ." Voice-activated input can also be a way to achieve nearly infinite adaptability. It may be a good practice to design interfaces, or entire products, that are technology-oriented around these more adaptable input devices.

Software (defined herein as "the coded information on a memory device that allows the user to control a device") can be replaced without discarding physical material. It is important that the components that comprise an interface (software circuitry, memory, input and output devices, etc.) are included in the product in such a way as to aid easy replacement. The more often a replacement will be needed, the more accessible these components need to be.

Method 7: Implementation of Modular Functionality

It is important when designing for emotional modularity to anticipate new functionality, and design products in a way that can facilitate these new functionalities as they arise. This category of upgradeability is particularly important in more technologically driven product genres, as buyers typically choose these products based more on their features than on aesthetics or user interfaces, and are therefore more likely to replace them if a product with better functionality becomes available.

Components that are the most likely to need new or improved functionality more often should be given the most accessibility. Anticipating new functionality requires the designer to be in touch with emerging technologies and user expectations in specific product genres. Reading monthly publications about design and/or technology will keep designers aware of the newest trends. It is up to the designers to use their creative vision to anticipate how these technologies will be used to meet emerging user needs.

CHAPTER 6: APPLICATION OFDESIGN APPROACH

This chapter will discuss the methods of Chapter Three as they apply to the design and development of a DVD (Digital Video Disc or Digital Versatile Disc) player. A DVD player is a device that allows playback of audio/visual data stored on a DVD or CD. Current DVD player designs allow the user to insert a disc into the device. This disc is then read and decoded, and the decoded information is sent via wired connection (RCA, component, HDMI, DVI, etc.) to a display monitor. It is comprised of a disc drive, integrated circuitry, user inputs (in the form of integrated button panel and/or remote control unit), user outputs (usually an integrated LCD display panel, in addition to the external television monitor), output jacks, interface software, and a power supply. These components are typically housed in a protective “chassis” or “frame” which is usually made from two or three pieces of stamped steel, and an injection-molded plastic front panel.

When beginning the design process, it is important to identify the problem to be solved. Asking the question, “How can we make a better DVD player?” will likely produce a product identical to the one described in the previous paragraph. While it may be better, it will most likely *not* be innovative, creative, or inspiring. Instead, asking, “How can we create a better device for accessing audio/visual information?” will create more opportunities for creativity and innovation, and produce a product that is more inspiring and pleasurable to use. The latter question will steer the designer toward a product which will meet user expectations, and predict and address changes in these expectations over time.

In order to identify changes in user expectation the designer must consider what challenges are most likely to cause technological or perceived obsolescence, and design the product to adapt to these challenges through modular design. The DVD's role is being eclipsed by audio/visual data stored and accessed over the World Wide Web. This data is instantly available for download from the user's home, often through file sharing networks, and offers more options for the user than a local entertainment retail or rental store. NetFlix and other mail order services, as well as local distribution solutions offered by RedBox, have attempted to revive the DVD by offering more convenient ways of renting or purchasing entertainment DVD's. However as of yet, the electronics industry responsible for creating the devices that DVD's are played on has not been competitive in trying to keep their products viable. These companies continue to produce "new" products with practically the same functionality, aesthetic appearance, and interface, with the only improvements being to the quality of video and audio that can be obtained from the disc. BluRay Disc was designed by Sony to offer higher quality data transfer in response to increasingly higher resolutions offered by new displays, and is not so much an innovative solution as it is an improvement on an existing solution. With the introduction of iTunes, Hulu and Slingbox, users are able to enjoy television and movie entertainment from mobile devices, introducing mobility to the list of user expectations.

Another aspect that contributes to the obsolescence of a DVD player is perceived obsolescence. Users want new experiences. Once a product becomes commoditized, the user may quickly grow bored with it and will seek a replacement that is new and exciting, even if the functionality of the product is nearly the same as the incumbent product that is to be replaced. Even if the quality that makes the product "new" is only the perception of the user.

With advances in audio/visual technologies happening so quickly, consumers need peripheral technologies that can keep pace. The purchase of a new television can make other products the user owns look or feel outdated. It is at times such as these that the user will consider replacing a DVD player with one that supports the latest in image and sound quality, as well as offering a new experience. It is for these reasons that a modular approach to DVD player design (as well as most, if not all other technology-driven designs) is necessary to provide users with products that will meet their expectations, and reduce waste caused by these ever-changing expectations.

It is important for the designer to examine the life cycle of each component or module to determine how it can be implemented with the least amount of negative environmental impact, while offering the most pleasurable experience for the user.

Method 1: Component Life Chart

It is important that before you take this step, you must consider how to deliver the benefit that the user is seeking to gain from the purchase of this type of product. This will help in identifying aspects or components of the existing model of DVD player design that are necessary, or unnecessary.

Attempt to anticipate future advances in technology related to data storage, data transfer, user interface, any infrastructure directly supporting the process of audio/visual playback. This will allow your component list to include components that are not yet part of the DVD product archetype, such as a network connection or battery.

It may be helpful to identify the component with a number or letter to use as a reference in later steps. An example such a list for the components of a DVD player is as follows:

1. Chassis – structural components that give the product its strength and mounting points
2. AV connection – changes often in response to advances in television resolution
3. Physical interface (buttons) & associated PCBs – likely to change layout and wear out
4. Processing PCB – includes memory, processors, and associated sub-components
5. Disc drive – may change to fixed hard drive soon into product life
6. Network Connection – likely to remain in the same format for long periods
7. Power supply – external converter box is suggested to allow for future change
8. Fascia – aesthetic and protective layer
9. Battery – necessary if designer anticipates a shift to mobile use in this product genre
10. Remote control – consider for advances in interface, as well as aesthetic changes

Identify the expected lifespan of each component based on fatigue, changes in technology, and changes in fashion. It is not necessary to invest a large quantity of time investigating the exact lifespans of the given components, as it is impossible to know absolutely how long each module is likely to remain viable. Also continue to examine each component from the above list for sub-components that could be replaced to increase the fashion, fatigue, or technological lifespans of their respective components.

The disc drive is a viable candidate for a single individual module. Comprised of motors and other moving parts, laser/lasers, laser reader/readers, and associated PCBs, subcomponents of this module will likely depend on each other in terms of technological obsolescence. In other words, if disc drives are replaced by hard drives, the motors that spin the disc and open the disc drawer, along with the laser and laser reader, will become unnecessary. It should be easy for the user or retailer to easily replace the disc drive module with a fixed hard drive module, using only simple tools (or no tools) in a short period of time.

Continuing with the disc drive example, it is likely that the function provided by the disc drive will be better served. As digital video media storage transitions from disc to hard storage, the disc drive will be replaced by (or supplemented with) hard drives capable of storing a library of digital video data. A fixed hard drive, or removable hard drive for storage of audio/visual data imported from an external source such as a disc or network connection will become necessary to meet new user expectations. It is likely that this change will be available before any component of the disc drive is physically fatigued. The current model of the DVD player is constructed to potentially last two or more decades under normal use. The disc drive will likely have no aesthetic influence, so it can be assumed that the lifespan of the disc drive will be influenced by or dependent on technological lifespan – more specifically, preferred data storage methods.

It was estimated for the purposes of this exercise that the technological lifespan of the disc drive module will be fifteen years. That means that every fifteen years, the support module for the storage and playback of audio visual information will be technologically outdated as users' expectations change. Given the currently popular method of acquiring data stored or transferred on the World Wide Web, rather than purchasing DVDs from retail chains, the first of these changes will likely happen in the near future – possibly five years or less. The designer must consider a component that allows the entire unit to be removed for a complete shift to hard storage, or one with docking points for a partial shift in which a small hard drive is attached to the disc drive. The latter would be preferred over the former as it allows longer use of parts that are already produced, but the disc drive will likely become completely obsolete at some point in the future, as evidenced by the VHS player.

DVD Component Life Chart

Component	Fashion Life	Tech Life	Fatigue Life	Notes
1 Chassis	N/A	50+ yrs	50+ yrs	Main structural component. Must not contain aesthetic elements. The one component that is likely not to be replaced.
2 AV Link	N/A	7 yrs	20 yrs	Limited by changes in format. Opportunity to use biodegradable or highly recyclable material.
3 Buttons PCB	N/A	15 yrs	7 yrs	Limited by fatigue. Technologically linked to changes in format. Design user interface to be adaptable to future changes in technology. Suggest use of "nondiscript" interface.
4 Processing PCB	N/A	15 yrs	50+ yrs	Limited by changes in format. Opportunity build in updateable subcomponent to increase tech life.
5 Disc Drive	N/A	15 yrs	25yrs	Limited by changes in video storage format. Must provide ability to replace with new format technologies such as hard drives or new disc formats. Opportunity to use biodegradable or highly recyclable materials.
6 Network Link	N/A	25 yrs	15 yrs	Opportunity to make component more durable. Attempt to increase fatigue life to 25 yrs.
7 Power Supply	N/A	50+ yrs	15 yrs	Use more durable or modular component. Consider using external power supply that can be easily changed to cope with future power needs.
8 Fascia	3 yrs	50+ yrs	50+ yrs	Limited by changes in fasion trends. Opportunity to build-in emotional modularity through modualr aesthetic. Must not have structural function. Bio-materials.
9 Battery	N/A	15 yrs	3 yrs	Limited by fatigue. Recommend standardized & proven battery size and type that can be easily changed and recycled
10 Remote Control	3 yrs	15 yrs	7 yrs	Limited by fashion. Main user/product interactive element. Technologically linked to changes in format. Recommend simple, timeless aesthetic. Use "nondiscript" interface.

Table 3

Group components into assemblies based on anticipated lifespans. This will serve as a basic guideline for combining components into modules that can be replaced during the same maintenance event.

DVD Component Groups

1 Chassis	3 Buttons	4 Physical Interface	8 Battery
	2 AV Connection	5 Power Supply	9 Fascia
		6 Disc Drive	10 Remote Control
		7 Network Connection	

Table 4

As seen in the development of the product life chart, the components can be divided into four basic groups based on anticipated component lifespans (see table 4). These groups do not necessarily dictate product architecture, but rather which modules could be or should be replaced during the same maintenance event.

For example, if the fascia and battery have estimated lifetimes of three years, then the two modules should be easily accessible during the same maintenance event without removal of any other module. It is also possible to combine them into the same module. However, this binds them together in terms of replacement, limiting the options for the user, and may lead to replacement of a module that has not reached technological or psychological obsolescence. In order to optimize the lifetime of these two modules they should remain separate, easily replaceable modules within the design.

Method 2: Component Relationship Wheel

Arrange the list of components of the DVD player in a circle (see fig .17). Draw lines of a chosen color between components that are related by anticipated lifespan (see fig. 18). In this case, the green lines between the components represent the relationship of the components by lifespans (also indicated by the color of the components representative number). It is likely that these modules will be changed during the same maintenance event, so it is important when designing the product that unrelated modules are not physically attached to one another.

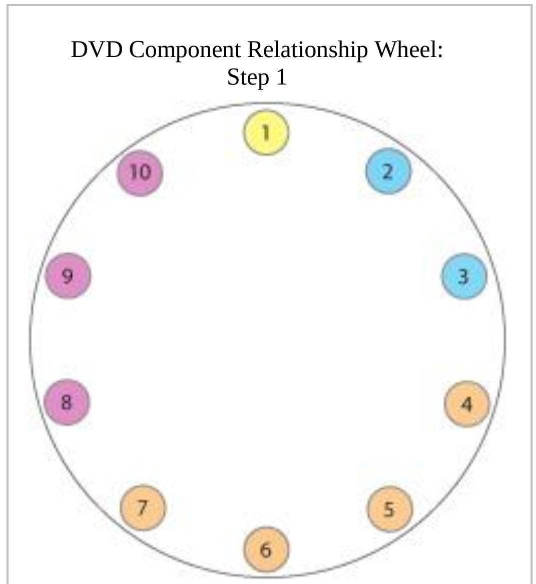


Fig 17

Draw lines of a different color between components that share a physical connection (see fig 19). In this case, the black lines represent physical connections between components that share a physical connection in the current accepted model of DVD player design. Notice that objects with different estimated lifespans are physically connected to one another. This means that in order to change the fascia – for example – the buttons and button control PCB must also be replaced, even though the buttons should be viable for four more years. This means that the lifetime of the button control module is not optimized.

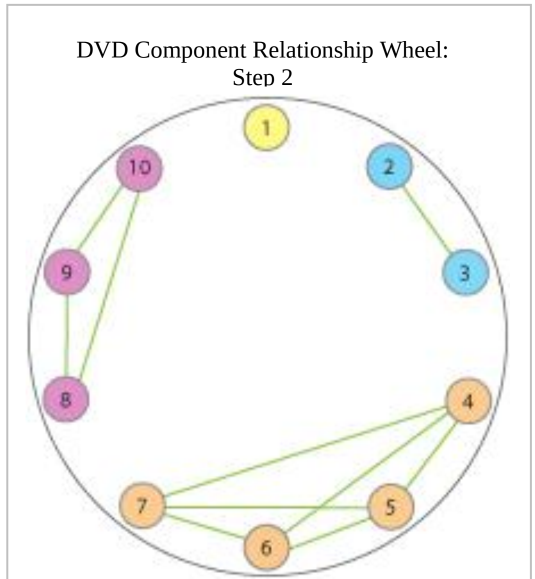


Fig 18

Two possible solutions are available to solve this problem:

1. The button control group can be produced with less durable, more disposable/recyclable materials, decreasing the estimated effective lifespan to three years.
2. The fascia and button module should be placed inside the DVD player in such a way that the fascia can be replaced without removal of the button control group.

DVD Component Relationship Wheel
Step 3

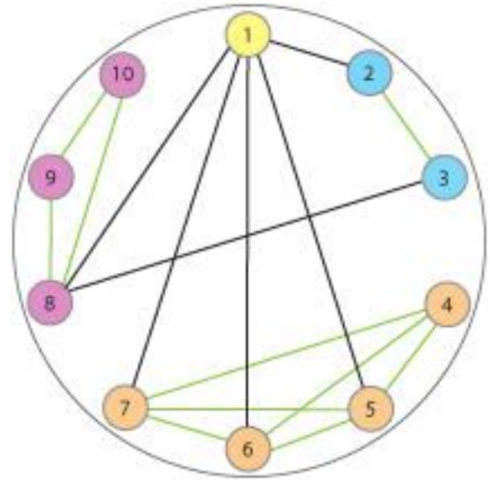


Fig 19

In the current model, the "chassis" or "frame" is the component to which every other component is attached. Unfortunately, the chassis in the current model is also the main external element, and therefore the most influential in terms of aesthetics. If the chassis is replaced to renew an emotional connection, every other component must be replaced, or they must be detached and then reattached during the replacement event. Making the frame an internal element, hidden from view, allows it to be used indefinitely (from a technological or structural point of view) throughout any possible module changes. Modules with limited lifespans can be attached to the chassis, or to other modules with the same estimated lifespan, allowing them to be changed without affecting modules with different lifespans.

Finished DVD Component Relationship Wheel

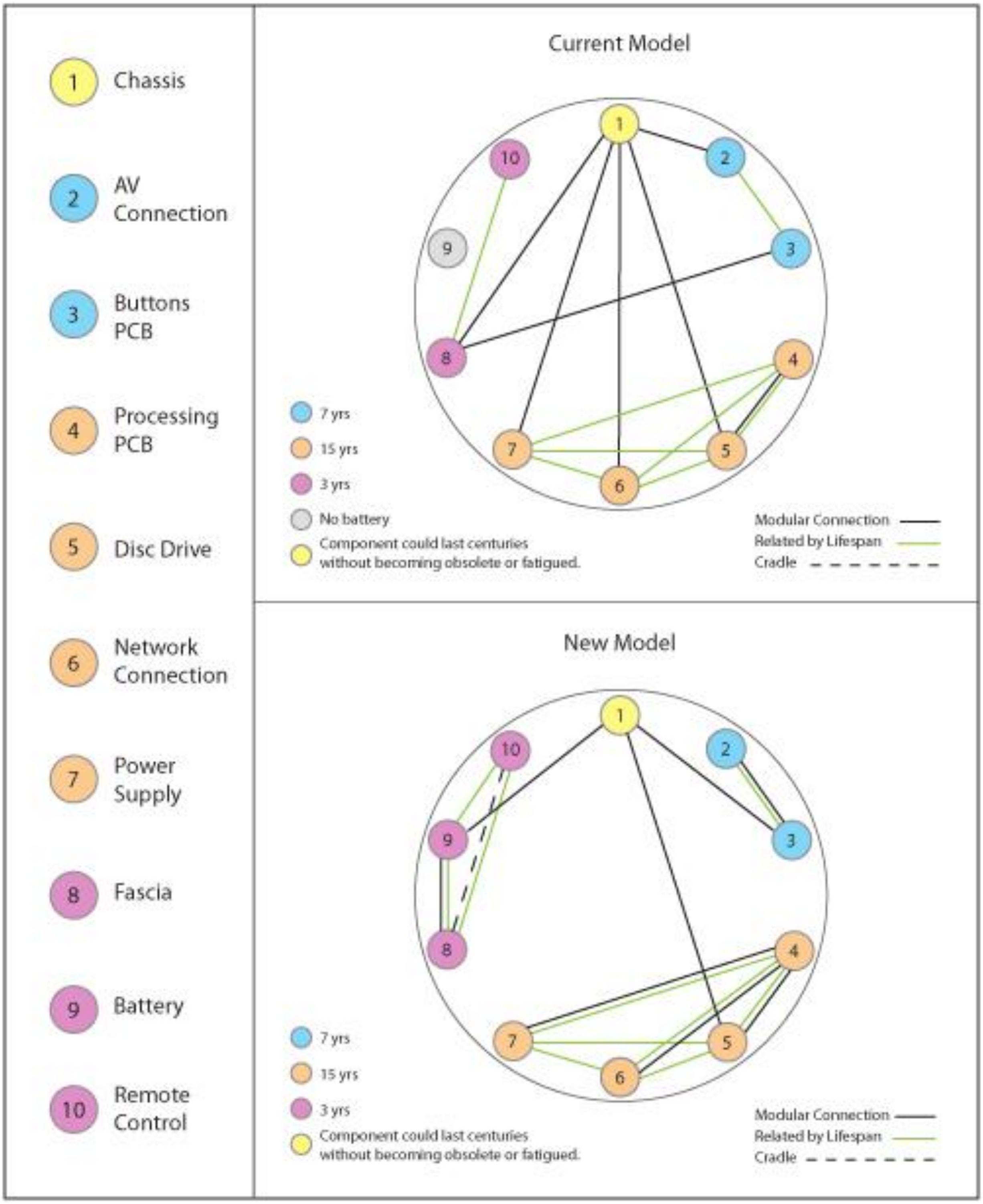


Fig 20

Exploratory Concept Sketches

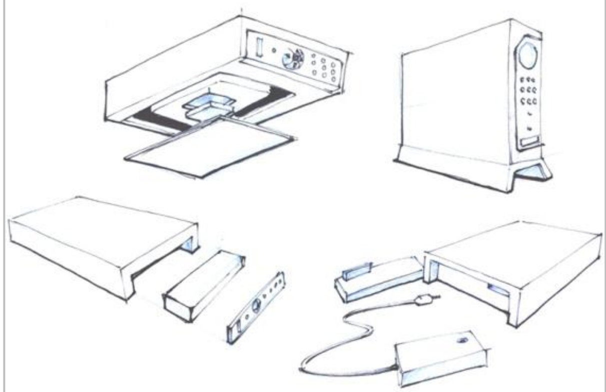


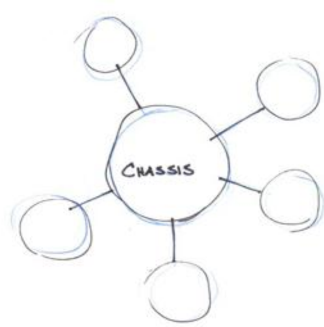
Fig 21

At this point, some exploratory sketches can be made to visualize the concept. The component life chart and component relationship wheel indicate that the best arrangement for the components is four basic component groups (modules), with the frame bridging the physical connection between the groups while allowing easy access to all modules (easiest access to modules with the shortest anticipated lifespans).

The modules containing the disc drive and associated PCB, as well as central processors will be placed at the core of the product due to their longer anticipated lifespans. Even though the network connection was evaluated to be placed into the seventeen year category, it must be accessible for the user. For this reason, the network connection will be grouped with the A/V connections and power connection, and given easy access from the exterior of the unit. A USB connection will also be added to this module to create an interface for future technologies and removable storage. The module containing the integrated controls (buttons) and associated circuitry will be placed outside the core, but beneath the fascia. Because the fascia has the highest potential for making the product "feel new," it will most likely be replaced more often than the others. Thus, the

Frame-in vs. Frame-out Construction

Frame-in Construction



Frame-out Construction

Fig 22

fascia will be designed as a “skin” that is easy for the user to change without hassle. The power supply will be a simple external D/C power converter, as it offers the most modularity, easiest replacement, and offers opportunities to use standardized parts common in the industry.

The placement of these components would provide justification for “frame-out” design architecture rather than a more traditional “frame-in” design; the frame-out design would consist of an inner frame – endoskeleton – versus an outer frame – exoskeleton (see fig 22). The internal frame allows for the easy swap of modules. Given this product architecture, preliminary concept sketches can be generated.

Due to the fact that electronic devices become smaller over time, it is unlikely that a rigid frame could remain viable until it is fatigued. Because it has no technological restraints, it may be beneficial to design the product with a frame that can become smaller – for example, a frame made up of smaller modules that can, over time, be used to house smaller and smaller components, allowing the overall size of the device to diminish.

Frameless DVD Construction

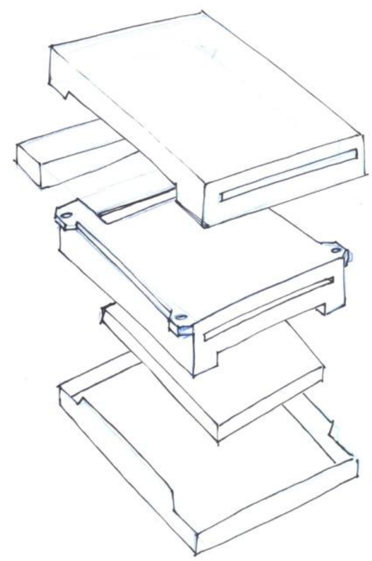


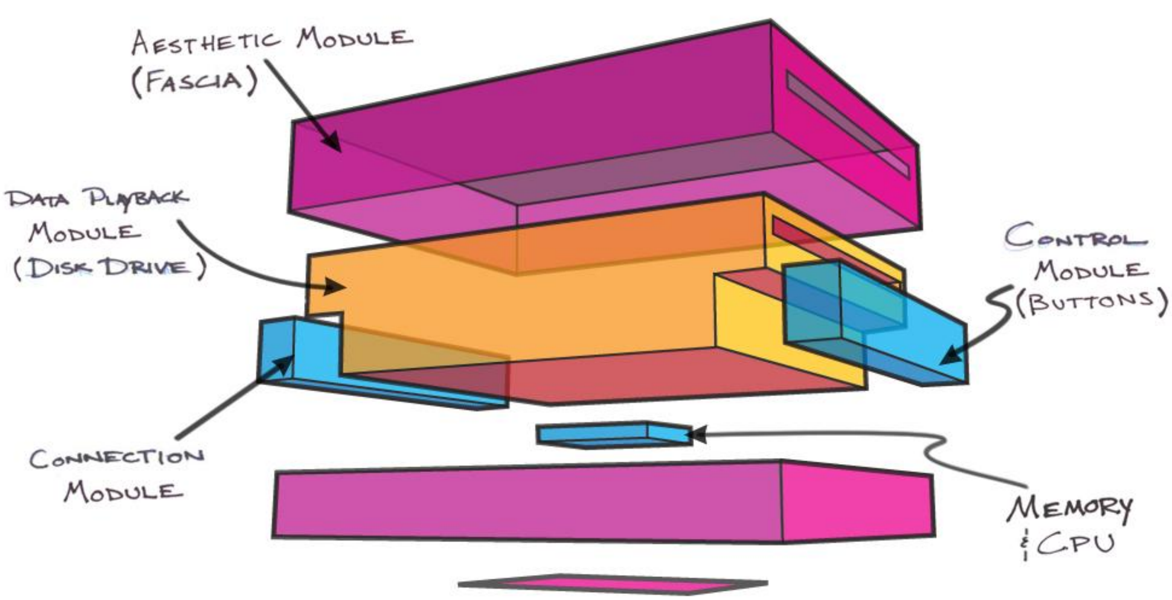
Fig 23

Another alternative to a “frame-out” design is to have no frame at all, but rather each module supporting the others, and contained in an external “skin.” This approach eliminates the problems caused by Moore’s Law, whereby speed and capabilities increase and the components get smaller. The device is free to reduce in size as the components inside the “skin” get smaller. This architecture will be defined herein as frameless product architecture (see fig 23).

Method 3: Hypothetical Timeline

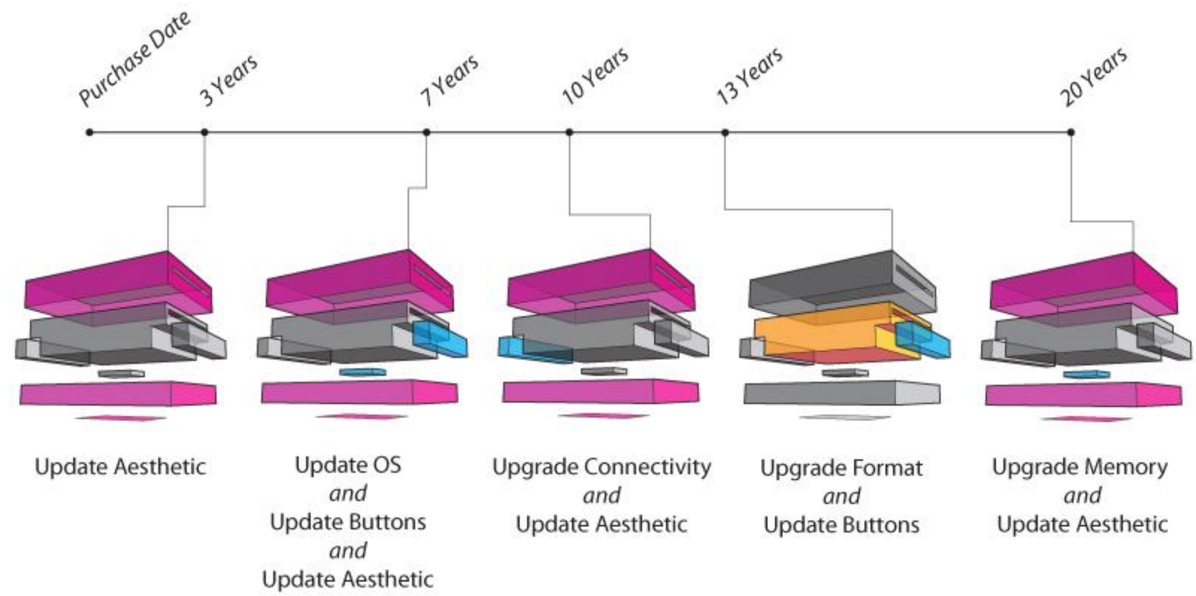
Illustrate a simple exploded view of the DVD player as it will be purchased. This view shows the product in its original (as purchased) configuration (see fig 24). The modules are color coded for easier identification. In the figure, the colors correspond to those established in the first two methods.

Illustrate a simple exploded view of the product after the first, second, and third module replacement event (see fig 25). Attempt to continue the replacement events until all module replacements are shown on the timeline at least once. At this point, a pattern should emerge, indicating which modules are likely to receive the most replacements. Information from the component life chart can help to identify which modules will be replaced during each maintenance event.



Exploded View

Fig 24



DVD Hypothetical Timeline

Fig 25

In this case, the aesthetic "skin" will be replaced most often, meaning it will be most susceptible to the fasteners fatiguing and breaking. It is advisable to use screws rather than snap-fit fasteners on this component. The drive (or "core") of the product will be replaced least often, so fatigue is not an issue, rather the component must use fasteners that permit a strong attachment point, as this component will support all other components in the DVD player.

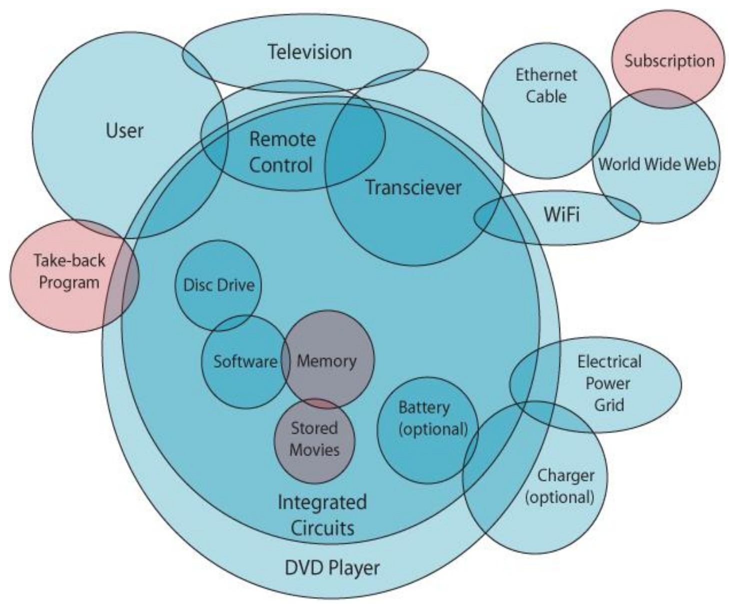
Method 4: Combining Service and Product Design

Rethink the benefit of the product. This is a crucial step of any design process. Before you can solve a problem, you first must understand the problem you are trying to solve. Break the benefit offered by a DVD player into its most basic form. The wrong question is, “How can we design a better DVD player?” Instead, ask, “What benefit does a DVD player offer the user who buys it, and how can this benefit be delivered in the best way?” The outcome from the first question will result in the creation of another DVD player, but asking the latter question could lead to the creation of a new category of product.

Create a Venn diagram for a DVD player using color to quickly identify aspects of the product that can be implemented with service design (see fig 26). This system examination did not include pre-purchase interactions such as retail stores, transportation, or manufacture.

Examining this system identifies a few opportunities for services to offer the user increased functionality with the product. Stored movie libraries, for example, can be stored, or even purchased or

Venn Diagram of a DVD Player



The more components or elements that can be moved outside the circle symbolizing the physical product (DVD player), the less physical components must be produced to offer the same functionality. This leads to less embedded energy use, less material use, and more ease of disassembly, and leads to a more sustainable design solution.

Fig 26

rented on a remote server to be accessed by the user from anywhere via the World Wide Web. To compete with new products such as Hulu and Slingbox, a service may be devised to allow users mobile access to movies rented or purchased online. Services can also be offered to update the user interface of the DVD player with new "themes" to renew emotional connection with the user. These new themes will provide new experiences, giving the user the feeling that they have received something new.

Given the nature of this product's modular structure, there is also an opportunity for services to provide take-back and recycling programs for used components. This gives the manufacturer control over the end-of-life of the components, allowing them to re-use components sent back from the user, providing technical nutrients for the cycle of re-use. While it is possible for users to do most of the maintenance and upgrades on their own, some upgrades may require special attention, giving rise to the need for services for repair and "dealer installed upgrades." These designed services can be offered in an all-encompassing package to offer a new level of usability, and to keep the user involved with the product, which should increase emotional attachment to the product as well as the manufacturer. This results in brand loyalty, as consumers are less likely to turn to a competitor to replace their existing DVD player, as they can continue to buy replacement parts from the manufacturer of their current product.

Method 5: Implementation of Modular Aesthetic

First, determine how technologically driven, or aesthetically driven the product is. As discussed in Chapter Three, products such as DVD players that are purchased based more on their technology than their looks must have more modularity to stay "new and exciting." While buyers of DVD players tend to focus more on features than on aesthetics (as evidenced by reviews, buyers guides, and the lack of visual diversity in the marketplace), they choose designs that are modern, thin, and visually unobtrusive with black being the most popular color. For a DVD player design to remain "modern and thin" by the standards of the time in which it is being judged, it must be able to change in appearance to mimic the "modern" trends as they change, as well as to become sleeker and thinner as technology produces smaller and smaller components.

To address the visual aspects of form, color, texture, lighting, shape, and size, a frameless architecture allows the product to have a replaceable "skin" that covers the unit, offering the user choices of different styles to better fit their home décor, personality, or current fashion trends. This same architecture allows the product to become thinner as smaller components become available. Because there is no frame (internal or external) that must fit inside (or outside) the product to hold the components, the product is free to become smaller in overall size, its removable skin covering smaller – or fewer – components.

Technology-Aesthetics Scale – DVD Player

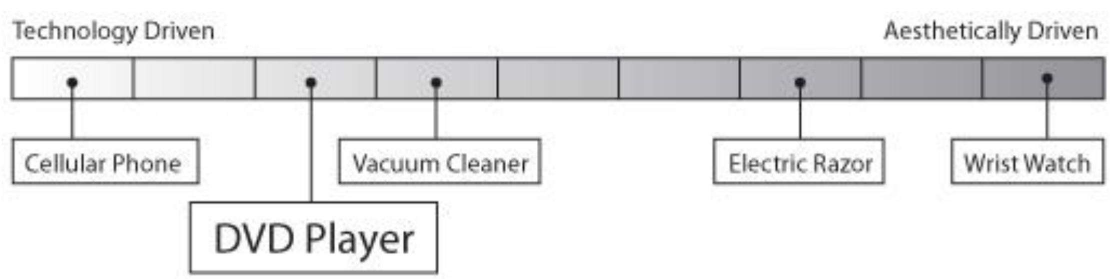


Fig 27

Method 6: Implementation of Modular Interface

Software-based systems lend themselves to easily updated interface. Although the button control and digital LCD display are part of the DVD player's interface, it is not the main component of the unit's interface. The main interaction occurs between the user with the remote control unit and DVD player through a graphic user interface (GUI). Graphical interface contained in the operating system software will greet the user every time the device is turned on, as well as provide navigation of features contained on the disc, or navigation through a web-based service provider. The high resolution television monitors which are standard today serve as a very adaptable output device for a GUI. They can display new graphics, or new "themes" contained in product updates or upgrades, and these updates can be made without discarding any components, as they can be stored digitally and downloaded from the World Wide Web with minimal energy use. Because universal remote controls are so prevalent, it is necessary to ensure that the player will work with as many different aftermarket universal remote control units as possible. This may require a chip to be installed on the central processing unit to recognize the signals sent to or from the remote control.

The user inputs incorporated into the DVD player itself are a little less versatile. A button-oriented interface – if designed carefully – can continue to support the functionality of product as it gains new or improved functions. A directional button pad, as found on most DVD player remote controls today, combined with non-specific buttons (such as buttons that use color to differentiate themselves) can accomplish a variety of tasks – both intended and unforeseen. While more adaptable interfaces, such as touchscreens, are available, they are expensive and require more development. Because the functions of "play, stop, pause, fast-forward, rewind, skip forward, and skip backward" will almost assuredly remain viable in the DVD player product genre – even as the genre evolves – it is reasonable to include these buttons as a permanent design element. However, should some unforeseen need arise to implement a different set of integrated controls into the design, the frameless architecture allows for them to be easily added, and a new external skin can be purchased fit the new button design.

Because the monitor needed for viewing the output form the DVD player can display so much information, the information that is displayed on the integrated LCD monitor can be reduced. In fact, the LCD monitor can be limited to a small numerical display, or may not be needed at all.

Method 7: Implementation of Modular Functionality

The frameless design architecture also allows for easy addition of new or improved functionality. With key components placed toward the outside, replacement becomes as easy as releasing a fastener, removing the old component, and sliding in a new one. The placement of the connection module, for example, allows the user to upgrade the component during an aesthetic replacement when newer, higher quality connections become available, or when a higher quality television or speaker system is purchased requiring new connection types. As mentioned, the buttons can be changed entirely if a new function is introduced to the product that the old button layout does not facilitate.

Circuit boards can be designed with removable chips or cards, similar to RAM or a graphics card in a PC, or the SIM card in a mobile phone. Easily removable outer panels can provide access to such components. Ribbons and other connections can be designed with unused pins or contacts that can be taken advantage of when the need arises. New functionality may have additional interface requirements to be considered when designing the updateable user interface.

The Final Solution

The design of a DVD player must meet a defined set of criteria. In the realm of professional design, some criteria are client-dependent such as cost, volume of production, brand message, etc. Other criteria are designer-dependent, or, more appropriately, user-dependent, as the designer must decide how to best appeal to the intended consumer, while staying within the constraints fixed by the client. These criteria are dependent on user research and the artistic execution of design on behalf of the designer. Because this project had no corporate client, all aspects were designer driven. The intended brand message was high end quality and sleek, modern styling, with high priority on low ecological impact, and close customer relationships with manufacturer. Cost is competitive with other mid- range DVD players ($100-150). Intended consumers are willing to spend a little more in order to purchase a more environmentally friendly product, yet still wish to gain high value for their purchase.

Final DVD Design

Fig 28

The player was designed with easily changed "skin" in the form of a thin injection-molded polymer. The top and bottom portion attach directly to the disc drive with screws. Matching covers hide the screws on the top side of the unit, while rubber feet hide the screws on the bottom. This fascia also adds structural support, keeping other modules in place. The module containing the buttons and associated circuitry are attached to the front of the disc drive module via electronic plug, with the buttons protruding through the fascia. The module containing the connective components (A/V, Ethernet, power etc.) is attached to the back end of the disc drive module with an electronic plug, and rests directly against an opening in the fascia. The central processors and other associated circuitry are attached to the bottom of the disc drive, and are accessible for subcomponent updates when the fascia is removed. The power supply is an external DC power

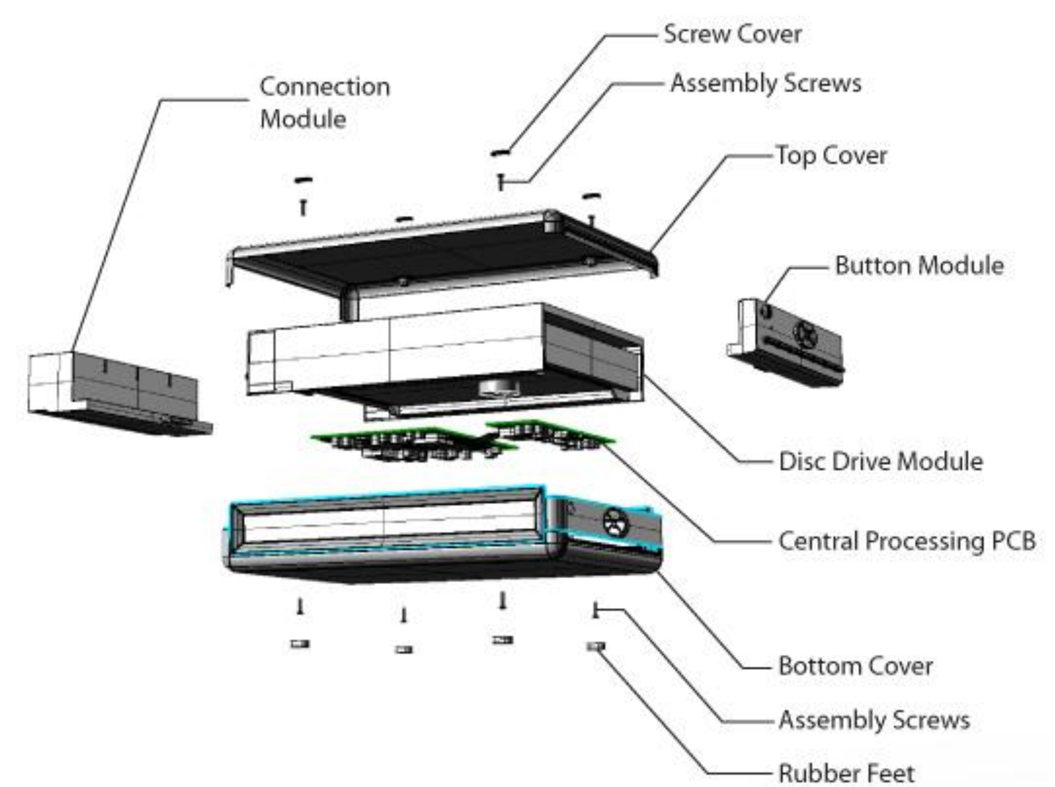


Fig 29: Detailed Exploded View of Final Design

adapter using standardized parts common in the electronics industry.

The product accomplishes an updateable aesthetic by utilizing an inexpensive, easily removed, low-impact, injection-molded polymer fascia. This highly recyclable or biodegradable petroleum-based or bio-based polymer will use very little energy to produce, and can be produced using high quantities of reclaimed material. Because the fascia will be made from one type of polymer, it can either be ground into new stock for future molding, or simply placed back on the assembly line to be incorporated into new units. In this way, the fascia can serve as a viable technical nutrient in a cradle to cradle cycle. Many different options will be available for the user so that they may customize their purchase to match their individual tastes or home décor. Incentives will be offered to consumers for the return of old components when making a replacement, thus allowing the manufacturer to responsibly manage the aesthetic component at the

Examples of Color Variations

Fig 31

end of its intended lifespan.

Further upgradability and personalization is available through multiple choices of connection modules (see fig 32). These modules can be easily replaced if the user purchases new video or audio equipment needing higher quality connections. Card readers for viewing pictures or video captured with digital cameras are an anticipated user expectation. Users will need ports for new storage devices as the will become a user expectation in this product genre. USB or other removable storage will allow users to take movies or television shows with them to be viewed elsewhere. The connection with the Web will allow the user to send any data they have stored locally to a cloud server that can be accessed from any location with an internet connection.

Possible Connection Module Variations

Fig 32

More functionality upgrades will be available in the form of an easily accessed central circuit board. It is understood that the complexity of chips and processors prevent changing some components. Processors and storage can be re-written, but cannot necessarily be changed, so the processing PCB will be easily accessed for change with simple, “everyday” tools such as screwdrivers. Ribbon-type connectors will link circuit boards to other components for easy replacement.

Perhaps the most versatile application of modularity will lie in the operating system software. Stored on a flash memory device, the software can be re-written, giving the DVD player a new graphical interface, and new color and graphic themes to be displayed on the monitor. Software will have energy saving features programmed into it. After sitting idle for a specified period of time, or after repeating the same looped information, the unit will turn itself off. This, in turn, will send no signal to the TV monitor, allowing the TV to save power. In order to allow looped playback in scenarios in which it is desired by the user, this feature will be among the user controlled settings available from the settings menu. This menu, along with every other operation of the player can be accessed either with the remote control, or from the button panel on the front of the unit. The button versatility of the directional button layout allows for navigation through DVD menus, as well as setting menus in player software. This button layout also will be adaptable to facilitate new features, allowing the button module to be used for longer periods without needing replacement.

Finally, the disc drive itself can be replaced to accommodate changes in format, such as a change to Blu-Ray, or a shift away from disc players to that of hard drive storage and playback. A shift to Blu-Ray may require nothing more than a change of laser reader within the drive, as well as circuitry that instructs the laser reader where to scan and how fast to spin the disc. It is anticipated that the laser-read disc will become obsolete eventually, as evidenced by storage methods of the past, such as magnetic floppy disks, Zip drives, and even punch cards. At some point the amount of data needed to store higher quality video will exceed the capability of these discs. The industry will be forced to develop new storage devices, and new tools to read them. At this point the user has two options, either to replace only the drive that facilitates playback, or to replace the system entirely. Given the nature of the intended consumer-manufacturer relationship, the user should be able to send the unit back, and receive a new unit at a discounted price. This allows the manufacturer to responsibly dispose of the unit, or to simply refurbish it (if necessary) and put the unit straight back into the production line to be sold as a complete product.

Current and Possible Future Concepts

Fig 33

Chapter 7: Conclusion

Future study should include in-depth cost versus benefit evaluation of implementing these strategies. In order to convince a company that these strategies will give them a competitive advantage, it must be proven that the end consumer will perceive a higher value in products designed with the methods in this study. This will require user research in the form of focus groups, interviews, co-discovery events, questionnaires, and prototype testing. It also requires inside knowledge of manufacturing costs, materials purchasing costs, tooling costs, labor costs, transportation costs, marketing costs, as well as other costs that will determine the cost to the manufacturer. Another area of future study is to implement these strategies on a number of different products from different product genres. This experimentation could be an effective part of an undergraduate sustainability class project. Still another area of future study is the long-term effectiveness of these methods.

With waste so rampant, and industry so eager to take advantage, and with such disregard for the impacts it is having on the planet and the people that inhabit it, it is necessary for all people – designers, manufactures, politicians, government agencies, and consumers alike – to start taking responsibility for their part in the cycle of consumption. The old strategy of eco-efficiency addresses only part of the problem, and only serves to do “less harm” rather than good. It is important to put new strategies into action that will serve to continue the prosperity brought about by new technologies, while providing a healthier environment in which to live.

The ideas presented in this study attempt begin that shift toward a more responsible existence by providing a set of tools for designers to use to make their products just a little more eco-friendly. If they can increase the lifespan of a product through creative design, they take a consumer out of the cycle of rampant production for a period of time. This means that fewer products are discarded carelessly to pollute our land, air, and seas. By offering the consumer an alternative to replacing an entire product, the designer has diminished the energy used to extract, process, and transport raw materials. The designer has decreased the energy used and pollution created during the manufacturing of these materials into useful products, and the transportation of the useful products to retail stores, where even more energy is used to get them into the hands of the consumers. By creating products that can fill the role of multiple products, the designer can optimize the life of the product to better take advantage of materials and energy used. Designing products that are easy to disassemble into usable raw materials optimizes the end of life of the products. Finally, by designing products with strong, updateable emotional connection with their users, designers can create pleasurable experiences.

It must be understood that a designer cannot use all of these tools at once in every situation, and that the designer’s preferences will continue to be overshadowed by the bottom line’s ability to influence final decisions. However, only by suggesting them, and defending them with examples of successful implementation can a designer hope to make a change. There are more and more examples of companies putting sustainable strategies into action with positive financial results, and designers must be aware of these examples and use them to attempt to sway decision makers in their respective companies. By learning to use the strategies set forth in this study, designers can gain an advantage in the face of looming governmental directives that will force companies to be more environmentally sensitive, putting those designers with previous experience in sustainable practices at the forefront of their industry.

As attitudes shift, and more evidence becomes available that we are living an unsustainable lifestyle, the public as a whole will become more open to making sacrifices in the name of sustainability, and industries will begin to see more advantages in implementing sustainable strategies. Imagine if this was the first step towards a world in which there is no waste, but rather a continuous flow of materials and energy from one form to the next, and the Earth's resources and balance of nature were preserved indefinitely. The methods outlined in this study will present designers with a logical approach to begin moving towards that ideal.

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Appendix: Glossary of Terms

Brand Image – The identity of a specific product, service, or business.

Bioaccumulation – A process by which chemicals are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical.

Cradle to Cradle – A biomimetic approach to the design of systems. It models human industry on nature's processes in which materials are viewed as nutrients circulating in healthy, safe metabolisms.

Cradle to Grave – Linear approach to design of systems in which there is a definite beginning and end.

Dematerialization – The absolute or relative reduction in the quantity of materials required to serve functions.

Downcycling – A process by which the quality of material is degraded each time it is recycled.

Eco-Efficiency – Creating more goods and services while using fewer resources and creating less waste and pollution.

Eco-Effectiveness – The central strategy in the cradle-to-cradle development method and seeks to create industrial systems that emulate healthy natural systems.

Emotionally Durable Design – A new genre of sustainable design that reduces consumption and waste by increasing the durability of relationships established between users and products.

Greenwashing – A term describing the deceptive use of green PR or green marketing in order to promote a misleading perception that a company's policies or products (such as goods or services) are environmentally friendly**.**

Life Cycle Assessment – A technique to assess each and every impact associated with all the stages of a process

Planned Obsolescence – The process of introducing a product with the knowledge that at some point a new product will be released that will render the first product obsolete

Service Design – The process of creating better user experience in the service industry

Sustainability – The capacity for a process to be maintained at its current means forever

Standardization – The process of developing and agreeing upon technical standards.

Systems Design – Genre of design in which products or services are designed with the bigger picture in mind. Each system is just a part of a larger system, and it is made up of sub-systems.

Technical Nutrients – Highly stable materials which can be used again and again, technical nutrients are designed to be retrieved and reused within the closed-loop cycle of sustainable manufacturing.

Technological Obsolescence – The result of the evolution of technology: as newer technologies appear, older ones cease to be used.

Technocentric – Placing high levels of importance on new technology and the products that use it

Technosphere – The system of industrial processes.

Transmaterialization – Process of turning a tangible product into an intangible service.

Update – A component or software change that allows the product function properly in response to changes in technology or other factors.

Upgrade – An improved component or software that replaces another outdated component or software to improve the function of the product.

User Experiences – The emotions felt by users when engaged in interaction with products or surroundings.