How Market Studies, Using a Systematic Approach, Can Inform Design Decisions

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Table of Contents

Abstract

A central focus of companies, from startups to large conglomerates, is to determine what products to build. Often, companies have the technology and knowledge to engineer and mass produce whichever design is created. The issue with products that fail is that the product is not what the consumer wants. To mitigate the chance of a company improperly sinking tremendous amounts of resources into a product, companies develop a “proof of concept” prototype to demonstrate the perspective functionality of the product. Using a combination of several concepts outlined in this paper, it can be hypothesized that systems engineers can use insight gained to build more accurate proof of concept models for their systems. The goal of this paper is to assemble a set of approaches, practices and tools that can be used by systems engineers to ensure that the correct system is developed. In addition, the paper will attempt to develop a unique methodology for developing and screening concepts.

1.0 Introduction

When designing a product, it is important to consider the three main aspects of the product design process. The first aspect is the marketing and data collection with regards to a product. Companies often must ask themselves “what system does the customer want?”. The second aspect of product design is to determine how to design the system. Ideally, after the designer has spoken with the primary stakeholders, they will have enough information to render a proof of concept of the product. The third and final aspect of product design has to do with engineering and maintaining the product. The product design process is iterative, and cyclical as shown in Figure 1.1. Generally, once a product is engineered it is shown to the end user for input, design changes are incorporated, and a new product is engineered. Almost all design philosophies reflect these basic criteria of how a product should be designed.

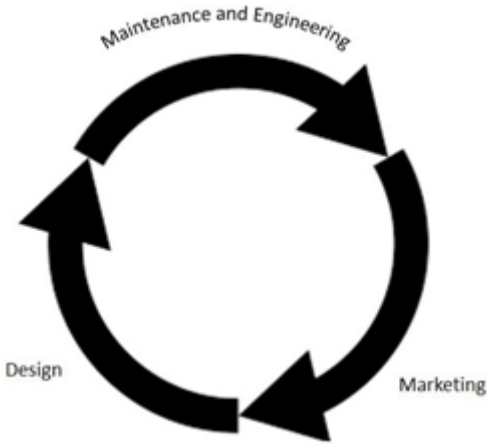

Figure 1.1: Basic Design Philosophy

It is worth noting that there are more components involved in the product design process, such as the preliminary product conceptualization. These have been left out as the scope of this paper is to illustrate the interplay between the marketing and the design of a product.

2.0 Background

The purpose and importance of this paper is underscored by the fact that the world's largest companies are interested in developing quality products that have sufficient markets. There is a long history of companies that were sufficiently skilled at engineering products but clearly did not research the market for the product and therefore built the wrong system.

One example of a product that was driven by engineering but did not observe the market for their system is the Concorde passenger airline. The Concorde was renowned for being the first supersonic passenger carrying commercial airplane. The Concorde was undoubtedly a feat of engineering but was marketed to a consumer population. The jet was marketed at people who needed to be at their destination as fast as possible and did not mind paying the extra associated cost. Unfortunately, that market did not seem to exist when it came to flights with customers who could afford the $8,196.28 (adjusted for inflation) ticket price. The upper-class passengers preferred to pay for the services that came with flying first class, even if a Boeing 747 took three times as long to reach the final destination. Ultimately, it was doomed to failure as the jet did not have the market or the profitability to sustain its use.

On the opposite end of the spectrum, an example of a product that is designed based on the marketing of the product is the Apple III. Apple co-founder, Steve Wozniak stated that “the primary reason for the Apple III's failure was that the system was designed by Apple's marketing department, unlike Apple's previous engineering-driven projects.” One of the Apple III’s main flaws was the inability to dissipate heat. Steve Jobs had determined that it was important, based on his marketing studies of the Apple consumer, that the Apple III have no fans or air vents. The lack of heat dissipation was responsible for major problems such as melting floppy disks. The lack of heat dissipation ultimately led to the demise of the Apple III and is an indicator of why the market need is not the only factor when developing a product.

These examples underscore the importance of a systems engineer and the application of this paper to different products.

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3.0 Different Methodologies for Product Design

The main purpose of this paper is to develop a set of different, pre-existing methodologies that systems engineers can use as tools to ensure that they are building the correct system. Therefore, three papers on product design and their approaches were examined in this section with a priority on determining how these approaches can be used to develop products.

The first paper is entitled *“Linking Marketing and Engineering Product Design Decision via Analytical Target Cascading”* which further describes the involvement and connections of marketing and engineering. One of the main principles this paper puts forth is that “if an engineer cannot deliver a specific product characteristic or some particular value of it, consumers are not asked for their reaction to it”. We only learn from consumers based on what technology is feasible. Engineering performs in the context that the model should maximize certain variables without knowing whether or

not the system will sell. The paper on linking marketing and engineering further describes the difference between models created by engineering and those created by marketing groups. The example given is that marketing groups use methods such as focus groups, test markets, surveys and measurement models and conjoint analysis. Engineers by contrast, attempt to meet more specific goals dependent of product and based on science. The paper uses the chart shown in Figure 3.1. to plot how marketing and engineering are interdependent through a concept known as Analytical Target Cascading (ATC).

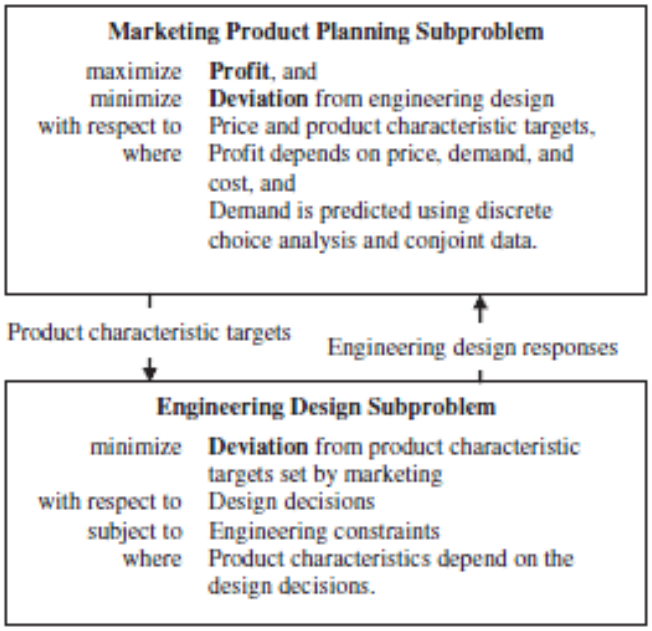

Figure 3.1: Analytical Target Cascading Formulation

Systems Engineers can take away several items from Figure 3.1. For one, the figure attempts to equate the design process like an optimization problem where the goal in both subproblems is to minimize the deviation in product characteristics. The model also describes how to take a joint planning and engineering design problem and decompose it into a product planning subproblem and engineering design subproblem.

At its core, ATC is a methodology for systems optimization that works by taking a complex hierarchy of different but related systems and dividing them. From there, each simpler system can be individually optimized. The paper further goes on to describe numerical methods for the maximization of profit in the Marketing Product Planning Subproblem by modeling that profit can be described in Figure 3.2 where Π is profit, $q$is the quantity of the product produced, $p$is selling price, $c_v$is variable cost per product and $c_t$is the investment cost.

$$\Pi = q(p - c_v) - c_t$$

Figure 3.2: Profit optimization equation

Overall, the Analytical Target Cascading paper gives insight on how to apply a numerical analysis to the integration of marketing and successfully adds a tool to the systems engineering toolbox.

Another paper comes from the Harvard Business Review titled *"Test Marketing in New Product Development"*. The focus of this paper describes one of the most crucial marketing practices of analyzing a product in a test market. The process by which Jay Klompmaker, the author of the paper, states the way one should analyze a product can be broken down in Figure 3.3. A test market is significantly important to a new product in that it can give the company an accurate insight of whether or not to kill the product or to go forward with it.

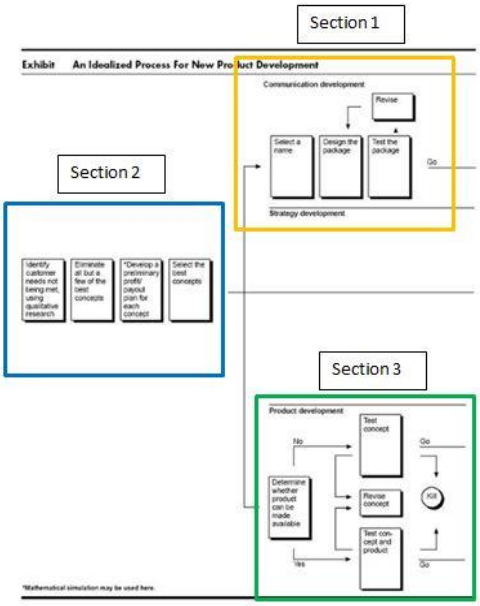

Figure 3.3: Idealized Process for New Product Development

The figure has been broken down into its three components below in Figure 3.4, Figure 3.5 and Figure 3.6 for visualization.

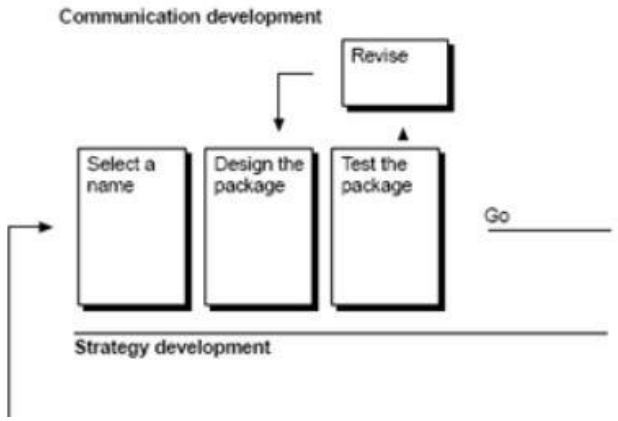

Figure 3.4: Section 1 - Communication Development

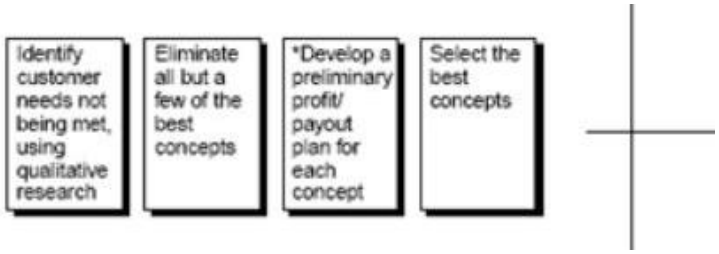

Figure 3.5: Section 2 - Identifying a need

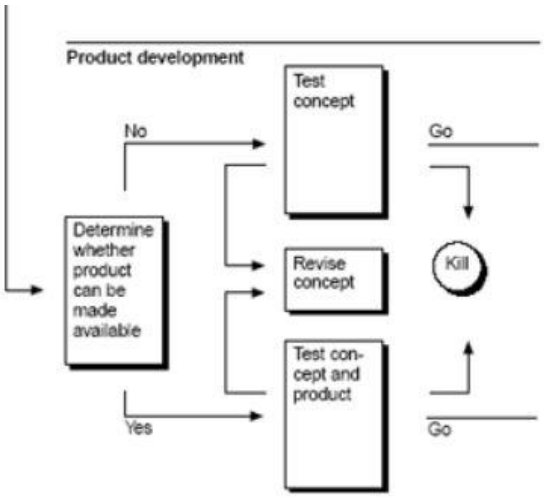

Figure 3.6: Section 3 - Product Development

There are several key takeaways that a systems engineer can use to add new tools to his toolbox. Namely, the paper gives the systems engineer feedback to the following pertinent questions:

- When should you conduct a test market?
- What can you learn from a test market?
- How should you use information from a test market?

The author starts with discussing the point that a test market is expensive and that if one is able to learn lessons without it, money will be saved. The author brings up an interesting point in stating that the number of products and product features selected in a test market should be variable based on the history and strengths of the organization. In other words, a company that has more resources such as capital and manpower in their product engineering department, will likely put out a product with more features and a few communication plans for each one. This as opposed to product with less features but a more throughout communication plan.

The next stage of a test market is to create a preliminary profit plan which can estimate the payout of each proposed alternative. Another significant takeaway from this article is the development of the marketing and communication strategy. The communication plan is an integral part of the overall project management process and can be seen in Figure 3.4. The final point is that a test market should be done when the company can accurately assume that there is going to be a successful product.

Another important question that has to be addressed when developing a test market is what the takeaways will be and how that can benefit the final product. The most obvious takeaway from the test market is what the consumer response will be. The test market will allow the company to measure levels of consumer awareness, product trial, repeat purchase, market share and sales volume - all of which will give an indication of the productivity of the elements of the marketing plan.

The final important question that a test market should resolve is how to utilize the data collected from the test market. The key that Klompmaker states is that test marketing should be used for evaluation, and not generation or development. He states that test marketing is the final step of a product that aspires to become a successful product. He also describes that the information can be used to extrapolate the results in the form of a mathematical market simulation which can be used to yield closer predictions.

A third and final paper titled “Democracy in Product Design” is an amalgamation of the first and second paper. This paper takes the quantitative concepts presented in paper on the ATC method and combines it with the second more qualitative paper about “Test Marketing”. In summary, the paper by Zsolt Katona puts forth interesting arguments relating to the validation and verification of a product. The paper propagates the concept of having customers of companies vote on new product designs. According to Katona, the concept is being utilized by an increasing number of firms. The paper details how this concept, referred to as democratic product design (DPD) is allowing

customers to provide validation and verification on significant product features. The paper gives the examples of Mountain Dew which allowed consumers to “vote” on the new flavor of soda. The main benefit from the customer standpoint is not only having their voice heard, it is the ability to hold these companies participating in DPD accountable. For example, when voting online, the poll results are typically made available after the customer votes. This forces the company to operate with complete transparency and create the product the customer wants.

There are some key takeaways a systems engineer can use to add to their tool box from this paper. The key question when considering using DPD to deploy a product is whether giving that much control to the consumer will interfere with the firm's fundamental strategic goals, such as differentiating its product. The paper proposes a model for calculating the effects of DPD on a business similar to a monopoly, where the firm controls the majority of the market share and a duopoly, where the firm controls less of the market share. The conclusions drawn are that, while the analysis Katona performs can be simplistic for a firm that does not have a monopoly on the market, it can be beneficial to utilize Democracy in Product Design to crowdsource decisions about a new line of products.

4.0 Applying System Engineering Principles

What differentiates this paper from simply a compilation of product design principles is the use of system engineering principles to integrate all of these concepts together to create a full methodology for developing products. Using a systems engineering perspective and the information above principles, a unique methodology was developed. The methodology would be tested in section 4.2 on a product that was previously developed for part of a Kickstarter campaign. Effectively, this product would serve as a case study and test for the methodology developed.

The idea of the methodology was to use the ideas of “Democracy in Product Design” to effectively crowdsource opinions on an existing product that can take multiple forms based on design iterations. Using the information gathered from “Test Marketing in New Product Development” a test market survey would be developed, and revisions would be made to the product using “Analytical Target Cascading”.

4.1 System Design

To combine all of these concepts into one, it was determined that a model would be built, and 50 end users would be surveyed. The model would be used to decide if a combination of the tools listed in these three papers could yield a better result and a more profitable product. The bases for the product would be a Kickstarter project that

this author developed five years ago known as the “Modu-Strip”. The Modu-Strip was chosen to perform this test as it yielded a product that many people were not yet familiar with, and something that possessed the potential to be largely customizable.

To provide background on the Modu-Strip, it was a crowdfunded product that was designed to reinvent the antiquated power strip. The Modu-Strip could be customized in multiple directions allowing a greater number of plugs for the user to utilize. There were several experimental features in development when the product was funded that were never added to the final product for time constraint reasons. These features would be the used as the experimental group in the DPD survey. The features are listed below in Table 4.1.1.

Feature	Price Increase	Description
Base Model	$7.00	1 "Outlet Blocks", 1 "USB Block", 1 "Circuit Breaker Module"
Wi-Fi Capability	$12.00	Allows each outlet to be turned off individually and remotely
Surge Protection	$6.00	Protects electronics from power surges
Second USB Port	$4.00	Allows for more charging
Extra Long Extension Cord	$3.50	Allows more flexibility when using plug

Table 4.1.1: Modu-Strip Features

The concept of DPD was utilized in a survey that was completed by around 50 end users where they would be empowered build their perfect product. All features that could potentially be added to the product would come at a price increase, thus the end-users could see how much their associated features would cost.

Many of the concepts discussed in the target market paper were useful in theory for this paper and not in practice since a product launch was outside of the scope of this paper.

The paper on Analytical Target Cascading provided useful insight for developing quantitative requirements for the product to meet. For example, the profit equation shown in Figure 3.2 was utilized to determine whether or not the feature would be viable.

Overall, these three papers and the numerous concepts proposed were integrated into a unique methodology which would be applied to the test case discussed above. The methodology can be visualized in Figure 4.1.1.

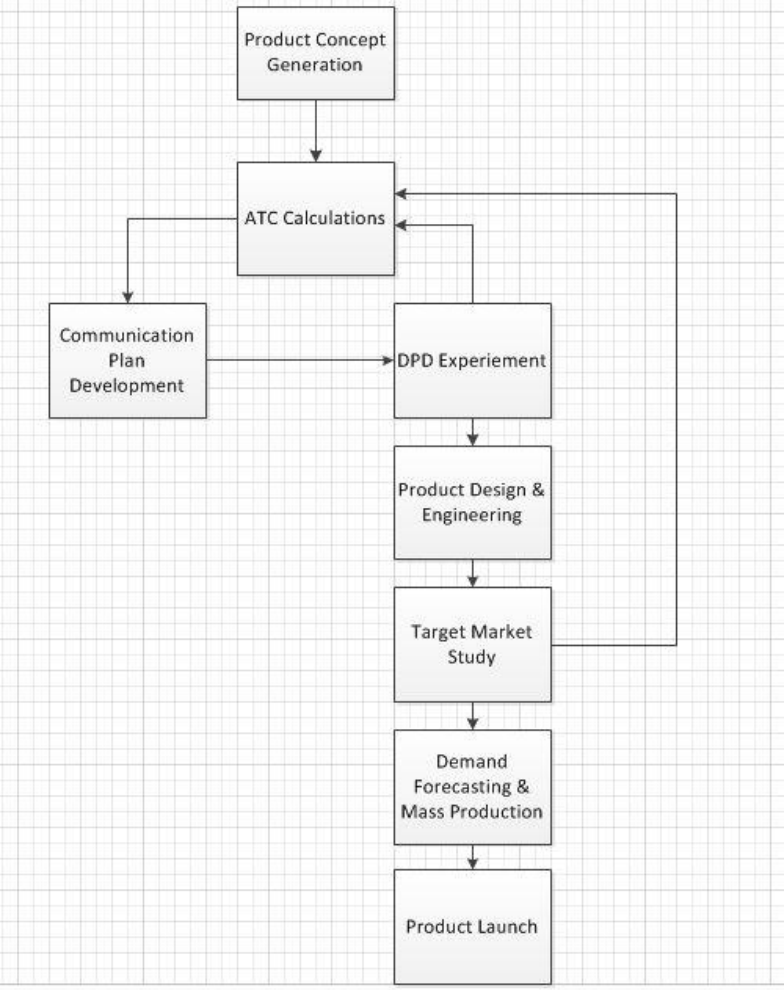

Figure 4.1.1: Unique Methodology for Product Development

4.2 System Implementation

The methodology was implemented by using a google form to simulate the first round of the Democratic Product Development process. It can be assumed that the ATC calculations and a preliminary Communication Plan were both developed in the time this product was initially conceptualized. The google form was given to 50 college students, which is this product's target market. In addition, a brief product marketing pitch was presented to the end-user to ensure that they understood the product at a basic level. A picture of a CAD rendering of the product was also provided to the end user. This picture can be seen below in Figure 4.2.1.

Figure 4.2.1: Modu-Strip CAD model

The end-user was also asked to answer questions within ten seconds to ensure that an accurate first impression was recorded. A full recording of responses can be found in the appendix.

5.0 Analysis of Findings

The responses of the questions were converted to binary and a basic analysis was performed on the findings. The results can be seen in Table 5.1.

Purchasing Product	Wi-Fi Capabilities	Surge Protection	Second USB	XL Extension Cord	Average Cost per Unit
81.82%	67.27%	50.91%	56.36%	67.27%	$20.33

Table 5.1: Summary of DPD results

There are several useful takeaways that can be gained from the findings. First, the product seems to have a significant theoretical market with 81.82% of the 50 respondents acknowledging that they would purchase the product. In addition, it seems that surge protection feature contains the lowest percentage of positive ballots. This could be useful in affecting the communication plan as one of the initially stressed features of the Modu-Strip was the surge protection feature. In addition, it can be noted that the cost the consumer would be willing to pay per unit is around $20.

The next theoretical steps would be to perform a revise ATC calculation, using these findings to inform the calculation and develop a new communication plan based on the chosen features the company decided upon. Following that, the company could either perform another DPD experiment to see if they could generate more positive responses or they could skip the second DPD phase and move on to the product design and engineering.

6.0 Future Research

One important flaw in the paper is there is only one surefire way to determine if a product is going be successful and that is to launch it. The next step in this paper would be putting more of the tools gained from the Test Market paper into practice and to actually have a test market where the consumers can purchase the product. One important point brought up in the Democratic Product Design paper is that, while the consumer may feel empowered by the ability to make choices on their product, their empowerment could become invalidated if the product does not meet their specifications. This could present a problem in the paper as the engineering and performance of the product was left out of the scope. In addition, the sample case of the Modu-Strip could utilize more iterations through the unique design methodology to further validate the product before the product was sent to be produced.

Additionally, it would be beneficial to review more papers about marketing and project management and integrate their concepts into the existing framework developed in this paper.

7.0 Conclusions

Overall, this paper provides a throughout insight into several tools that a systems engineer can use to gather marketing data on a product they wish to develop. There are several limitations placed on the paper that would still need to be proven. One major limitation is that an actual test market was not used. Since the product would not be built, the consumer would have no real way of validating the product. This is justified, however, as being outside the scope of this paper. The idea is that, given marketing and design knowledge, the perfect system can be engineered. Another key limitation was the narrow scope that this paper covered in terms of the design process. While the paper did address marketing and design of a new product, it did not tackle the idea of engineering limiting the technology that could be developed.

8.0 Appendices

Britannica, The Editors of Encyclopedia. “Concorde.” Encyclopedia Britannica, Encyclopedia Britannica, Inc., 6 Apr. 2018, www.britannica.com/technology/Concorde.

Katona, Z. Quant Mark Econ (2015) 13: 359. https://doi.org/10.1007/s11129-015-9164-z

Klompmaker G, Jay E., and David Hughes Russell I. Haley. “Test Marketing in New Product Development.” Harvard Business Review, 1 Aug. 2014, hbr.org/1976/05/test-marketing-in-new-product-development.

Michalek, J. J., Feinberg, F. M. and Papalambros, P. Y. (2005), Linking Marketing and Engineering Product Design Decisions via Analytical Target Cascading. Journal of Product Innovation Management, 22: 42-62. doi:10.1111/j.0737-6782.2005.00102.x

“Modu-Strip: The Modular Power Strip.” Kickstarter, www.kickstarter.com/projects/254043234/modu-strip-the-modular-power-strip.

Wozniak, S. G. (2006), iWoz: From Computer Geek to Cult Icon: How I Invented the Personal Computer, Co-Founded Apple, and Had Fun Doing It. W. W. Norton & Company. ISBN 0-393-06143-4.

Timestamp	Are you interested in owning a Modu-Strip?	Are you interested in Wi-Fi Capability?	Are you interested in Surge Protection?	Are you interested in a Second USB Port?	Are you interested in an Extra Long Extension Cord?
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7/31/2018 19:10:32	Yes	Yes	Yes	Yes	Yes
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20:45:31					
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