Framework for Customer Interaction Throughout the Automotive Product Development Process

by

William F. Biberstein

Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Engineering and Management

at the

Massachusetts Institute of Technology

February 2002

Signature of Author _____
William F. Biberstein
System Design and Management Program
February 2002

Certified by _____
John R. Hauser
Thesis Supervisor
Kirin Professor of Marketing, Sloan School of Management

Accepted by _____
Steven D. Eppinger
Co-Director, LFM/SDM
GM LFM Professor of Management Science and Engineering Systems

Accepted by _____
Paul A. Lagace
Co-Director, LFM/SDM
Professor of Aeronautics & Astronautics and Engineering Systems

Framework for Customer Interaction Throughout the Automotive Product Development Process

by

William F. Biberstein

Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Engineering and Management

ABSTRACT

The focus of this thesis is to determine if the program teams of original-equipment-manufacturer A (OEM-A), a global automobile manufacturer, are isolated, to some degree, from their targeted customers. Qualitative research (interviews) was conducted to determine the degree of customer interaction and the needs of program teams for customer input during the product development process. In addition to defining the current state of market research at OEM-A, informal market research conducted by program engineers (independent of the market research activity) is summarized based on a ten-month sampling.

Research results support the hypothesis that some members of OEM-A's program teams are isolated from customer interaction during the product development process. In addition, research results indicate the market research and marketing activities at OEM-A were not completely aware of the needs of program team members for customer input. Three primary challenges are identified for effective market research during OEM-A's product development process:

- Executive and program level decisions are made using customer input
- Improving product developer's market-research skills and access to related tools
- Collaborative market research between the market research activity, marketing and the program team members

The needs of program teams relating to market research are identified and linked to existing market search methods. Based on respondent recommendations, actions are proposed to assist OEM-A in satisfying the three primary challenges identified for effective market research. One of the potential actions includes a proposal for a new market research framework developed to address the specific challenges at OEM-A. Future research (quantitative surveys) is recommended to determine the extent that qualitative results represent the entire product development organization at OEM-A.

Thesis Supervisor: John R. Hauser

Title: Kirin Professor of Marketing, Sloan School of Management

Acknowledgements

The completion of this thesis is the culmination of my participation in the System Design and Management program. Challenging coursework and the interaction with MIT faculty and SDM students from various industries has provided me with significant learning opportunities. The knowledge gained throughout the program has benefited me both personally and professionally. Successfully completing the program requirements was enabled through the contributions of numerous individuals.

The value of this thesis to my employer was enabled due to the expertise of M.I.T. professor John R. Hauser in the field of market research. His supervision during the thesis development provided evidence of his knowledge of both market research and his accurate perspective of industry. I am especially thankful for his patience during the evolution of this thesis.

Without the significant sacrifices made by my wife Joan during the past two years, I would never had been able to complete the SDM program. Throughout, she patiently endured my frequent absences while caring for my son Erik and our newborn twins, Anna and John. With our fourth baby (a boy!) due this coming May, the completion of this thesis required significant sacrifices by my wife that I can only hope to repay one day.

Erik, Anna, and John, my children, have patiently endured the frequent absence of their dad. I cannot begin to count how many times our son Erik, who is now five years old, has asked me, "Dad, when are you going to be done with school?" The frequent hugs from my children gave me the energy needed to keep going.

The support of my managers, Troy Dehne and Walt Bielski, throughout the SDM program has been amazing. I doubt that I would have completed the SDM program and this thesis without the accommodations these individuals made to my workload and schedule. My co-workers also supported me during absences required by the SDM program.

Participation in the SDM program required a significant financial investment by my employer, OEM-A (disguised for confidentiality). I continue to be amazed with the generosity of OEM-A in sponsoring the majority of the program-related costs. My hope is that OEM-A's investment will pay significant returns.

The written acknowledgement of these individuals and my employer cannot accurately represent the magnitude of their contributions. I will be forever indebted and thankful for the support they provided in making this thesis and SDM degree possible.

Table of Contents

List of Figures:

Glossary:

- CAB = Customer Advisory Board
- CS = Customer Satisfaction
- D&R = Design and Release
- DVP&R = Design, Verify, Plan and Report
- FMC = Ford Motor Company
- FMEA = Failure Mode Effects Analysis
- GM = General Motors
- MR = Market Research
- MRA = Market Research Activity – organization within OEM-A
- MSRP = Manufacturers Suggested Retail Price
- NBS = Needs Based Segmentation
- N.H.T.S.A. = National Highway Transportation Safety Administration
- N.A. = North America
- NVH = Noise, Vibration, and Harshness
- OEM = Original Equipment Manufacturer
- OEM-A = OEM "A" - a global automobile manufacturer
- PD = Product Development
- PDP = Product Development Process
- QFD = Quality Functional Deployment
- SDS = System Design Specification
- SUV = Sport Utility Vehicle
- STOC = Securities Trading of Concepts
- Team-X = a program team at OEM-A
- VCI = Virtual Customer Initiative
- VOC = Voice of Customer
- WMO = Women's Marketing Organization

Chapter 1: Introduction

The Goal of Automobile Manufacturers

As with any industry, the ultimate goal of automobile manufacturers is to make a profit from its operations. In order to make a profit, automobile manufacturers must have revenues from product sales that exceed the costs of development, production, and warranting their products. Don Reinertsen [1] indicates that *"profit is simply a measure of how efficient we are at converting time and resources into things people value."* It seems reasonable to equate the profits a product produces to the surplus value it provides to customers relative to the cost of production. To better understand how customers define value, an equation is often used to relate value to function and cost:

$$Value = Function / Cost$$

To the customer, cost is the price they pay plus any non-monetary costs. Function is the ability of the product to fulfill customer needs. Using the value equation, auto manufacturers can increase customer value by reducing a product's costs and/or increasing its function. Although this simple relationship can help a program team remain focused, the answers to the following questions are needed to develop a value proposition:

- Who are the targeted customers?
- What are their prioritized needs?
- Will the value of the proposed product exceed that of existing products?

The purpose of defining a targeted customer is to provide a focus for the program team and the business case development. Considering that many models will sell to thousands of customers, it is a necessity to understand the number of customers that share

similar needs relating to their automobile. The population of potential customers is typically segmented or sorted by the marketing activity in many different ways. For example, pick-up truck customers could be segmented by their demographics (ex. age, sex, income, and marital status), their lifestyle (ex. outdoor enthusiast, family carriers), their occupation (ex. construction contractor, professional), and their product/emotional needs. Based on experience, some market research professionals believe that demographics and lifestyle do not predict customer purchase patterns nearly as well as a focus on customer needs.

Using market research (MR), the prioritized customer needs and the targeted customer are defined to help the program team efficiently execute the appropriate vehicle's design. The purpose of MR is to reduce the uncertainty in estimating the actual appeal of a given product. The estimated value of reducing uncertainty or financial risk is what justifies the MR expenditure. The prioritization of customer needs allows the program team to efficiently distribute limited financial and engineering resources.

The value proposition of a new product is what attracts potential customers. Customers will purchase the product that provides them with the best value proposition. Unfortunately for automobile manufacturers, many different approaches remain with regard to creating value in the minds of perspective customers. For example, a customer who requires the storage and occupant seating capacity of a minivan may ultimately select a sport utility vehicle (SUV) to satisfy a greater need for image. For another customer who cares less about their image, a minivan may satisfy their needs for passenger capacity and superior fuel economy.

Examples of Potential Outcomes

The purpose of MR is to reduce the uncertainty as to how potential customers will view the product. Industry publications indicate that a majority of automobile companies conduct some amount of MR in support of a major product development execution. Therefore, the challenge is not to do MR per se, but to do the right MR at the right time to appropriately influence product decisions. This implies that the organization must have the capability to distinguish "good" and "bad" MR. This discerning capability emanates from knowing what MR method is appropriate and when it is best utilized.

Two vehicles competing in the relatively new "crossover" segment provide contrasting sales results: Pontiac Aztek and the Chrysler PT Cruiser (Figure 1.1). The crossover segment is viewed as the evolution of the SUV (popular in the 1990's) towards more car-like attributes in ride and handling. Both vehicles have won coveted industry awards. The PT Cruiser was voted as Motor Trend magazine's 2001 "Car of the Year" award. Similarly, the Aztek won the J.D. Power "Appeal" award as judged by surveys of new vehicle owners. J.D. Power is an independent market research firm.

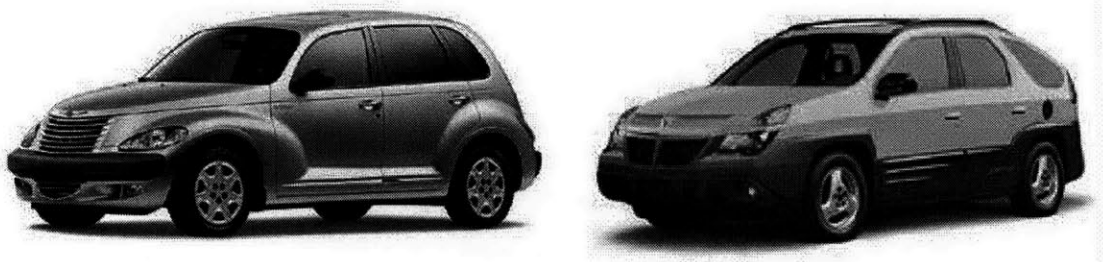


Figure 1.1: Chrysler's 2001 PT Cruiser (Left) and GM's 2001 Pontiac Aztek (Right)

The sales and media evaluations of the PT Cruiser and Aztek have produced significantly different results. Industry publications place year-to-date sales [2] (Jan-Nov.'01) of the Aztek at 26,093 units versus published [3] annual objectives of 50,000-60,000 units. In comparison, the year-to-date sales [4] (Jan-Nov '01) of the PT Cruiser are 132,041 versus published [5] annual objective of 150,000 units. Slow sales of the Aztek were especially disappointing when considering the advertising exposure it received as the sponsor of the inaugural "Survivor" television series. The PT Cruiser has yet to offer financial sales incentives, which were common on the Aztek [6].

Media publications tend to highly rate the functional performance of both models [7, 8]. However, writers for automotive magazines seem to favor the styling of the PT Cruiser over the Aztek. In the absence of a considerable product or pricing deficiency, it seems plausible that MR, conducted during the development of both vehicles [9, 10], factored in the degree of market acceptance of both products. One hypothesis is that MR conducted in support of the Aztek PD may have over estimated the appeal of the product. Similarly, it is possible that MR conducted in support of the PT Cruiser underestimated the appeal of the product as evidenced by the addition of production capacity in the Mexican assembly facility and a new assembly plant in Germany.

Bob Lutz [11], the vice-chairman of product development at General Motors (GM) who oversaw the development of the PT Cruiser at his former employer asserts, *"instead of fixating on data about consumers, GM needs to tap into their* [the customer's] *emotions."* If the media has portrayed Mr. Lutz accurately, he is someone who places more value on using one's own instinct to make decisions and less value on MR. Mr. Lutz articulated his opinion of the Aztek in a recent newspaper article [11]:

"You do have to ask yourself how the Aztek got through the system. It's still hard for me to understand how in a group of automotive professionals nobody would have said, 'hey, stop.'"

The Pontiac Aztek and the Chrysler PT Cruiser illustrate varying levels of success in satisfying the value proposition of customers. As expected in any large company, it is often difficult to ascertain with certainty the decisions critical in determining the relative success of these two products.

Decision Making

Conducting MR, even if it provided perfect information at the exact time it was required, is not a guarantee for success. In addition to data accuracy, MR must influence decision making throughout the PD process to produce potentially successful products. This implies that the entire product development organization would need to be able to distinguish between good and bad MR and associated strengths/weaknesses.

Immediately after obtaining a bachelors of science in mechanical engineering in 1990, the author began his professional career working for original equipment manufacturer-A (OEM-A) in the Light Truck Division. "OEM-A" is the disguised name of a global manufacturer of cars and trucks that will be referenced throughout the balance of this thesis. At the time, the truck division was responsible for the development of pick-up trucks, vans, and sport utility vehicles (SUVs). One of the author's first assignments was working in the customer evaluation section that supported the product development of OEM-A's compact pickups and SUVs. The customer evaluation section reported to the program's chief engineer. The primary responsibility of this section was to conduct drive evaluations to compare the performance of current and proposed OEM-

A products to their respective competitors and to provide customer input to product engineering.

The majority of investigations, conducted using employees, involved evaluators who were not current or potential customers of the product in question. Instead, the majority of "customer" evaluations were conducted using experts for various vehicle attributes such as vehicle dynamics, powertrain performance, and noise/vibration/harshness (NVH). Following the evaluations by the functional experts, the program managers would perform similar evaluations. In this case and throughout this thesis, "program managers" refers to any manager, supervisor, or chief engineer assigned as a member of the program team. It was unusual to have an evaluator who was a current customer and inexperienced in vehicle evaluation. These product evaluations usually focused on generating quantitative data for the functional performance of OEM-A and competitive products. Although the sample size of respondents was small (usually less than 15 individuals), the statistical significance of the survey results was rarely questioned.

One experience stands out in relation to the utilization of MR to support decision making, In 1990, one of the executives in the truck division requested that the locking strategy be revised on OEM-A's compact SUV to require all doors to unlock with a single turn of the key in the driver's door lock. A "customer" evaluation was performed outside of one of the engineering facilities that included competitive vehicles and other vehicles with unique unlocking strategies. Respondents, from various engineering activities, completed both a physical evaluation of the properties and a short questionnaire.

The majority of female respondents expressed a dislike of a single key turn to unlock all doors. Specifically, the female respondents feared that an attacker could jump into their vehicle from the passenger side if all doors were to open with a single key turn. After being presented the results and recommendations from the survey, the executive questioned the validity of the test methods. A second survey, which was conducted with only minor modifications, produced similar results. Thankfully, the design of the locking strategy proceeded without the addition of the proposed unlocking strategy. Ironically, a recent internal news article documented how one of OEM-A's European models was receiving customer complaints for a key fob (hand held lock/unlock transmitter) that unlocked all doors simultaneously. In this case, there was no option to only open the driver's door with the key fob.

These experiences left the author feeling somewhat confused. How had OEM-A's light truck products become so successful when employees were utilized as surrogates of the voice of the customer (VOC)? How could OEM-A's program managers lack, to some degree, an intuitive sense of the female customer's perspective while selling many compact SUVs to female customers?

Maintaining a Customer Focus

For the CEO of OEM-A, focusing the corporate vision and strategy on the customer is a key enabler to sustaining profitability. In February 2001, the CEO of OEM-A spoke to a group representing business, academia, and government. He indicated that a consumer-focused company would exhibit the following "seven" signs:

1. *"Your customers are your partners"*
2. *"You communicate with your customers using dialogue versus a one-way sales pitch"*
3. *"You offer great products"*
4. *"You deal with your customers using a relationship headset versus a transaction mentality"*
5. *"Your employees interact directly with customers and have the sensibility of small business owners"*
6. *"Your employees have direct, ongoing experience with the Internet"*
7. *"Your brands have ongoing, genuine identities that allow customers to make both a rational and an emotional connection"*

Large product development organizations like OEM-A will be challenged to consistently rate highly in the seven categories of a customer-focused company. Given the complexity of customer types and their needs, the product development is further challenged by the complexity of three thousand plus components engineered by a team of more than five hundred members. Challenges presented by government regulations and competitive products further complicate the development of automobiles. In addition, new products are continually being launched that provide customers with an improved

value proposition and manufacturers with the need to continually improve their product offering. Many who work in the automotive industry would likely agree that challenges like these make it easy to lose focus on the customer during the development of a new automobile.

The evolution of minivan features, specifically the number of doors, illustrates how automobile manufacturers can struggle to maintain a customer focus. Chrysler Corporation, recovering from near bankruptcy in the 1970's, began minivan production for the 1984 model year with the Dodge Caravan and Plymouth Voyager. The Chrysler minivans were designed to provide transportation for families. Chrysler's minivans were based on a car architecture (integrated body and frame) that provided a low step in height and the driving stability of directing engine power to front wheels. Until this time, most minivans were based on a truck architecture (separate body and frame) and were driven by the rear wheels. The Chrysler minivans were constructed with conventional swing doors for the driver and passenger, a sliding door on the passenger side (i.e. right-hand side), and a lift gate for accessing the rear cargo area.

General Motors (GM) and Ford Motor Company (FMC), who had been producing truck-based vans (Chevrolet Astro and Ford Aerostar respectively), began developing products to compete with the successful Chrysler minivans [12]. GM released a new series of minivans for the 1990 model year: Pontiac Transport, Chevrolet Lumina APV, and the Oldsmobile Silhouette. In a similar move, Ford Motor Company launched the Mercury Villager in the 1992 model year and the Ford Windstar in the 1995 model year. All of the GM and Ford minivans shared a similar architecture to the Chrysler minivans including a single sliding door on the right-hand (passenger) side of the vehicle.

The debate regarding a left-hand (driver) side sliding door erupted when Chrysler released the feature as an option on the redesigned 1996 model year Chrysler minivans. News media [13] indicated that Chrysler's MR estimated two-thirds of buyers would purchase the $400 optional fourth door and that it would increase to three-quarters when customers were aware of safety features designed in support of the added door. Specifically, Chrysler had engineered a feature to prevent the added door from opening into the fuel fill door during refueling. In addition, a mechanism was provided to enable the sliding doors to be opened only from outside of the vehicle. The locking feature would address owners concerns of having children exit into the street side traffic.

Chrysler's MR results were supported by independent sources. In 1995, a survey conducted by Auto Pacific [14], a MR firm, found that 70% of minivan owners would pay $250-$300 more for a "passenger door" on the driver's side.

Like Chrysler, FMC conducted MR regarding the potential for adding the driver-side door. However, FMC's MR did not support the addition of the driver-side door. In 1995, the Windstar chief engineer, David Ford, gave the following explanation for the lack of a driver-side door [15]:

> *"A driver-side door was originally part of the Windstar program* [1995 MY] *but there was conflicting research about what customers wanted. Some customer have a safety concern because they don't want their kids to get out of the vehicle on the street side."*

In 1996, the Windstar brand manager, J.C. Collins, gave the following explanation for the lack of a driver-side door in an Automotive News article [16]:

> *"In our research in the late 1980s and early 1990s, one-third of customers didn't want a fourth door. It was a coin toss for another third. And one-third wanted it."*

In the view of industry analysts, being the only domestic minivan to offer a sliding driver-side door provided Chrysler with a significant advantage over competitors. Customer acceptance of the driver-side sliding door resulted in a 78% installation rate [16] on Chrysler minivans, which supported Chrysler's MR results. Subsequent revisions to the GM and Honda minivans in 1997 and 1998 model years respectively included the driver-side sliding door. GM's plans for a right-hand drive model for sale in Britain meant that the left-hand side sliding door was relatively easy to add after Chrysler's success [17]. For the 1998 model year, FMC released a larger (six inches larger) driver door and a tip/slide driver's seat as a stopgap measure until their release of the driver-side sliding door in the 1999 model. Industry experts [18] estimated that Ford spent in excess of $100 million dollars to enlarge the driver's door for the 1998 model year. FMC's Mercury Villager and Toyota Sienna minivans received the driver-side door for the 1999 model year.

Thesis Statement, Strategy, and Outline

It is impossible to accurately predict the amount of sales Ford lost due to a lack of a driver-side sliding door. However, the fact that FMC spent a significant amount of money for a larger driver's door for a single model year and an additional sliding door would seem to indicate that the losses were significant. Plausible hypotheses for FMC's decision to not add a driver-side sliding door include any one or a combination of the following items:

- FMC program-team members were isolated from MR participation
- MR underestimated the desirability of the feature
- FMC senior management discounted MR data
- Functional degradation such as driver's seat frontal crash performance [19]
- The program team had limited engineering and investment resources

Every automobile manufacturer, including OEM-A, has experienced a time when their product offerings were substandard to a competitor's features In addition, it is likely the hypotheses proposed in the Windstar case could exist in any automobile company. The focus of this thesis is to determine if the product developers at OEM-A feel isolated from the voice of the targeted customer (VOC) and if so, why. Qualitative research will be conducted to determine the needs of product developers in accessing their customers throughout the product development process. Although interviews will include members of the program team and supporting activities, a special focus will be given to design and release engineers. The reason behind this strategy is that the majority of team members designing and testing components/sub-systems are more likely to be

isolated from customers than the rest of the program team. Although important, less focus will be given to established MR methods such as those used to estimate volume, revenue, and the grouping of features into option packages.

The program team needs will be linked to existing MR methods to develop a new framework for customer interaction throughout OEM-A's product development process. In addition, actions will be proposed that address the specific challenges found at OEM-A in maintaining a customer focus.

Chapter 2 provides a historical view of the automotive industry and feature evolution. In addition, the chapter provides a section on the future of the industry and a review of OEM-A's product development process. Chapter 3 provides a brief review of MR methods and tools. In addition, the theoretical and actual MR practice is discussed. In Chapter 4, the results from employee interviews are presented to substantiate the needs of OEM-A's product developers and the challenges that prevent VOC integration into the product development process. Chapter 5 maps product developer's needs for customer interaction to existing MR tools/methods and proposes a new product development framework. Recommendations are made to address the challenges to VOC integration. Chapter 6 summarizes research findings and provides recommendations for future research.

Chapter 2: Automotive Industry Background

The purpose of this chapter is to provide the reader with a perspective of the evolution of the automobiles design in the United States (U.S.) and the product development process used at OEM-A. This perspective should help the reader to understand that the practice of focusing product actions on customer needs is not a new phenomenon. In addition, the reader will gain an understanding of the basic process used to develop an automobile at OEM-A

Automobile Design Evolution in the U.S.

At the turn of the twentieth century, views varied regarding the potential for the automobile to become a standard method of transportation. William C. Durant, who formed General Motors in 1908 by merging the Buick Motor Car Company, Oldsmobile, and several smaller automobile companies, had predicted annual sales of 500,000 vehicles would eventually be reached in the United States [20]. His predictions, although seemingly unbelievable to some at the time, would eventually prove to be significantly understated as annual sales in North America in the 2000 calendar year reached 17,752,797 units [21]. Using Mr. Durant's predictions and the 1908 census estimates [22] would have produced annual sales of one automobile for every 177 U.S. inhabitants. In comparison, actual 2000 calendar year vehicle sales and census data [22] produced an annual sales rate of one automobile for every 15 US inhabitants.

In the U.S. automotive industry, the rate and focus of change in automobile design (both styling and functionality) has varied. This section will illustrate how customer

needs drove the evolution of the automobile in the U.S. Specifically, examples will be provided in the following areas of vehicle development:

- Function
- Styling
- Safety
- Architecture

"Function"

By 1900, 8,000 cars were registered in the U.S. [23]. A popular model at this time, the Oldsmobile, sold for $650 (nearly half the price of competitors). High volume production began in 1914 when Henry Ford, the founder of FMC, opened the world's first assembly line to produce the Model T that sold for $290. Production of the Model T increased to 472,000 from 78,000 in 1912. The assembly line increased production rates and provided substantial cost reductions, which provided less affluent Americans with affordable automobiles.

Competition in the U.S. automobile industry was significant. According to Ward's AutoWorld, there were 485 independent car builders in the United States in 1903 [20]. The majority of this first quarter century focused on developing automobile technologies that would meet the customers' basic needs for functionality and could be profitably mass-produced. With automobile design unregulated, competitive and legal pressures drove automobile design development.

To start the engine in early automobiles, vehicle owners would have to crank a handle at the front of the vehicle to begin the combustion process in the engine. It was common for the crank handle to react uncontrollably during engine starting, which

sometimes resulted in significant injury to the now "cranky" owner. The invention of the electric self-starter by Charles F. Kettering in 1911 allowed customers to push a button within the occupant area to start the engine. GM installed the first electric starters on their 1912 Cadillac model [24].

Many of the first automobiles provided occupants with little protection from inclement weather. As a result, the occupant area was enclosed via the addition of a roof and windows. The addition of standard glass windows was followed by the first use of "shock-proof" glass in 1926 that would improve occupant safety during glass breakage [23]. Enclosing the occupant area facilitated the development of heating and cooling for the occupant areas. One early design solution trailed the use of engine exhaust gases to heat the occupant area. Fortunately, the use of water heated during the engine operation became the primary method of warming passengers.

Customer needs for improved functionality, especially safety, continued to motivate product design. Early automobiles, often called "horseless" carriages, were missing one critical item, the braking capability provided by the horse. Early brake designs required the driver to pull a handle to apply a friction surface to one of the wheel. As vehicle speeds increased, drum brakes were introduced at each wheel to improve stopping capability. The series of cables connecting the drum brakes at each wheel to the brake pedal would stretch unequally (due to varying lengths) during usage. Uneven cable stretching produced unequal braking force that made the vehicle prone to spinning out during braking. As a result, hydraulic brakes were eventually introduced in 1921 [26] to distribute equal braking force to each wheel and assist the driver in developing enough force to stop vehicles that were becoming heavier and faster.

"Styling"

Thirteen years after the introduction of the assembly line, large automobile manufacturers were able to utilize economies of scale to reduce costs and lower vehicle prices to consumers. As a result, hundreds of manufacturers were either absorbed by competing manufacturers or went bankrupt. By 1927, the number of U.S. automakers was reduced to 44 [24] from 485 in 1903. With the basic automobile architecture defined, the industry was able to redirect competitive energies towards improving the styling of their automobiles. Alfred P. Sloan, the president of GM beginning in 1923, pioneered an "annual restyling" to stimulate vehicle sales. Sloan was quoted in his book, *My Years With General Motor* [27]:

> *"The degree to which styling changes should be made in any one model run presents a particularly delicate problem. The changes in the new model should be so novel and attractive as to create demand for the new value and, so to speak, create a certain amount of dissatisfaction with past models as compared with the new one, and yet the current and old models must still be capable of giving satisfaction to the vast used-car market."*

Sloan's strategy promoted significant exterior and interior styling revisions to occur frequently between subsequent model years. This practice was eventually adopted throughout the U.S. automotive industry [24].

"Safety"

Until the 1960's, the U.S. government had not regulated the product design practices of the automobile industry. Although safety was certainly important in the minds of the customers, the automobile industry seemed less interested. Early efforts to improve automobile safety focused primarily on driver training, automobile maintenance, and road improvements [24].

By 1965, fifty thousand people were killed every year in automobile accidents in the United States [28]. Ralph Nader wrote a book titled "Unsafe at Any Speed" in 1965 criticizing the safety of GM's Chevrolet Corvair and the automotive industry as a whole. GM eventually stopped producing the Corvair in 1969, which had declining sales volume [24]. Following public pressure, the 1966 U.S. congress passed the National Traffic and Motor Vehicle Act, which allowed for the creation of the National Highway Traffic Safety Administration (N.H.T.S.A.). Government regulations regarding occupant safety resulted in technological advancements such as safety belts, bumpers, and tempered glass. These actions, along with other regulations regarding vehicle driving and crash performance, significantly reduced automobile deaths. Further reductions in serious injury and death would require a technological solution to the fact that vehicle occupants could not be forced to utilize the provided restraints. In addition to not viewing safety belts as necessary, some customers felt the safety belts themselves might pose a risk to passenger safety. The solution to this challenge, made almost twenty years later, led to the development of air bag technology, which provided passive (requiring no passenger action) protection to the front seat occupants.

"Architecture"

The fuel shortages in the 1970's prompted American consumers to consider purchasing imported vehicles form Asia. The Asian vehicles, primarily from Japan, were affordable and fuel-efficient. Even though the Asian imports were much smaller than the typical domestic product, customers were now willing to trade size for fuel efficiency and price. Customer preferences shifted from cars to trucks with the minivan, popularized by Chrysler in the late 1980's, and the sport utility vehicles (SUV). Many customers needed the space of a station wagon and the desirable image provided by the SUVs.

OEM-A's Product Development Process

The purpose of this section is to present an overview of OEM-A's product development process (PDP) and its inherent complexity.

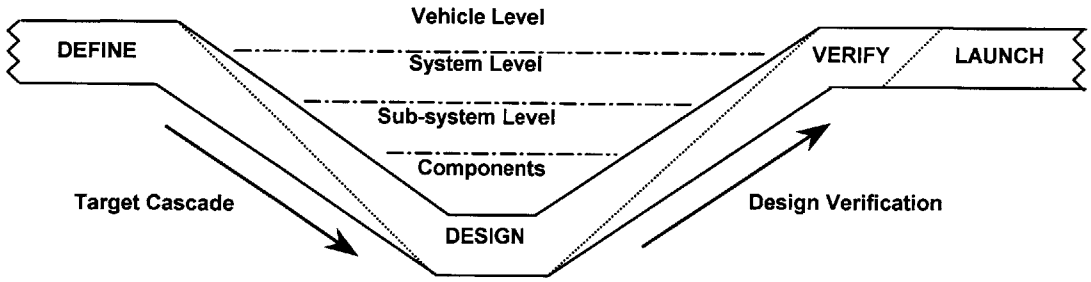
"Product Development Process Overview"

The purpose of the PDP is to define the necessary tasks and deliverables to be completed by organizations and individuals in the production launch of a new or revised automobile. Internal company documents distributed via the Intranet show that OEM-A's current PDP is the sixth substantial revision since the early 1980's. Before the current PDP, revisions were primarily focused on providing refinements in timing and nomenclature for a high-level description of the expected development process. The current PDP was released in 1997 following a significant initiative to incorporate systems engineering principles to manage the complex automobile systems. Systems engineering

principles, such as those defined by Chestnut [29], focused on specifying vehicle-level performance requirements which were subsequently decomposed to component-level engineering requirements.

Figure 2.1 illustrates the four main phases in the OEM-A PDP: Define, Design, Verify, and Launch. Detailed documentation is provided to describe the specific tasks and associated deliverables to be completed by the various organizations supporting the product development process. Ten program milestones (not shown) are defined to indicate the progress of a program team during the PDP. The PDP links each deliverable to the milestone it supports. Generic milestone timing is scaled to accommodate the degree of product change for a specific product program.

Figure 2.1: High-level view of OEM-A's Product Development Process



OEM-A's PDP is managed as a stage-gate process [30] with cycling occurring as required during the target cascade and design verification (as shown in Figure 2.1). Cross-functional program teams, including marketing and manufacturing, progress towards a management review at each milestone. Critical deliverables are reviewed versus established objectives to support milestone approval. The level of management participating in each review varies by milestone. Specifically, formal reviews are

conducted between the program team and senior management to obtain approval of the following items:

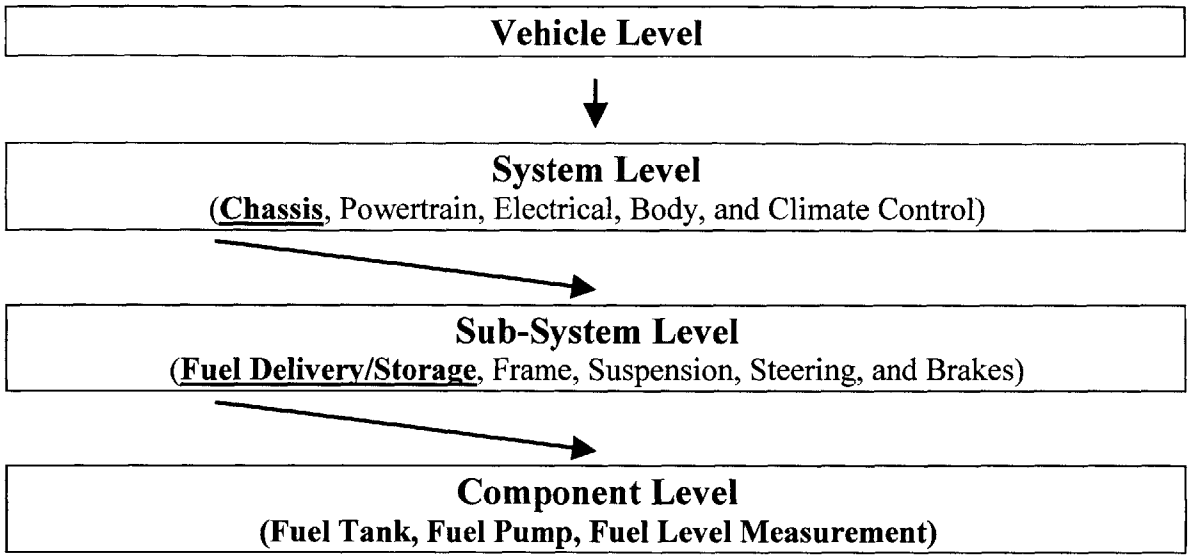
- Proposal for a new or modified product
- Strategies to address the target customer's needs
- Plan to execute the final product, manufacturing and business strategies
- Functional capability of pre-production automobiles versus functional objectives
- Start of mass production

The define phase of the PDP is the start of program specific work. Before this phase, a basic business opportunity has been established and incorporated for specific start/production timing in the corporate cycle plan. The define phase consists primarily of translating customer needs into product concepts. The selection of product concepts, i.e. "the recipe," that will result in an acceptable proposition from a business and customer perspective is the primary deliverable for this phase. Supporting strategies (such as manufacturing, part commonality, marketing) are developed to describe how the product assumptions will be executed. Requirements defined by customers, government regulations, and the corporation are defined at a vehicle level and are then cascaded to system, subsystem, and component levels. The total number of product requirements, numbering in the thousands, is managed in a web-based database.

Figure 2.2 shows an example of the decomposition of the fuel system. For example, a vehicle-level requirement/target may be established that the vehicle travels 400 miles on a full tank of gas. The chassis, body and powertrain systems would participate in cascading the vehicle-level requirement down to various contributing system, subsystems, and components. Requirement/target cascading is required to ensure

that each level of design can be verified against some performance measure that supports the vehicle level targets, i.e. what the company sells to consumers.

Figure 2.2: Example of Vehicle Decomposition for the Fuel System



The design phase is the second phase in the PDP. In the beginning of the design phase, engineers develop documentation to support the development of robust designs. Before designing the actual parts, engineers will evaluate design concept for potential failures and the likelihood of their occurrence using an FMEA (Failure Mode Effects Analysis). A test plan will be created (DVP&R – Design Verification Plan and Report) to verify that the failures will not occur during customer usage and that the product satisfies the cascaded design requirements. If the define phase produced the product "recipe," the design phase consisted of choosing the specific "ingredients" from multiple alternatives.

The verify phase is the third phase in the PDP. The purpose of the verify phase is to ensure that the customer is "getting what they ordered." The verify phase consists of using CAE (computer aided engineering) and physical prototypes to verify that the design

levels will indeed satisfy product requirements and not exhibit undesirable failure modes. Verification begins using lab testing of component level testing and advances through subsystem, system, and vehicle levels. For example, the results of component verification testing are used as input into the next higher design level (subsystem in this case) before completing CAE and lab testing. Verification test results at each level are subsequently inputted into designs at the next higher level. Drivable prototypes are eventually built that include all of the refinements made during lab and CAE testing.

The launch phase is the fourth and final phase in the PDP. The primary purpose of this phase is to ensure that the validated designs can be manufactured (per the tolerances specified on the engineering drawings) in volume using production tooling and processes. Further, the launch phase exists to ensure the component designs can be assembled at production assembly rates. The vehicles produced during the launch phase are utilized to confirm that the results of prototype testing remain valid for the production-tooled components.

"Complexity Overview"

The previous section provided a simplified view of the automotive product development process utilized by OEM-A. In practice, product development at OEM-A is viewed as being extremely complex and rarely referred to as "simple." The complexity of product development at OEM-A can be viewed from the following perspectives:

- Parts and performance
- Cycle time and competition
- Scope

The number of parts assembled by OEM-A into a vehicle typically numbers between three and four thousand. For an existing product, the numbers of parts that will require new tooling will vary and may be as high as 80%. Before releasing vehicles to customers, approximately five to six thousand requirements will be verified using various test methods. The performance of any component, subsystem, or system will be affected in some way due to the interaction with other components, subsystems, or systems. The vehicle system may be required to operate in a wide range of environments and usage: from –40F to 150F, from sea level to the mountains, from the shopping market parking lot to a remote dessert location, from single to multiple occupants, from a quick trip to a long journey, etc.

The goal of the automobile manufacturer is to identify a market opportunity such as demand in excess of capacity (ex. SUV in the '90's), unmet customer needs (driver side sliding door on minivans), and/or an unmet product need (ex. Chrysler PT Cruiser). If the manufacturer has correctly estimated the potential profitability of satisfying the identified customer needs, the task moves to successfully translate those needs into products before competitors can release a similar product or the customer's needs change.

The scope of the product development effort can vary significantly for OEM-A between products receiving only minor modifications to all new vehicles. A large program team for OEM-A can involve hundreds of dedicated and shared employees for a time span of two to four years. Some of these team members will report directly to the program managers or to the functional activities operating outside of the program's control. The design and release (D&R) engineers are solely responsible for formally releasing a drawing that embodies the desired fit, form, and function of every item

shipped to the vehicle assembly plant. D&R engineers are typically faced with a multitude of variables to optimize and input from various organizations. Optimization variables for any component of the automobile include:

- Manufacturability
- Serviceability
- Ease of assembly
- Durability
- Affordability
- Reusability
- Reliability
- Weight
- Operations
- Package

Influence regarding the priority and specific execution of the component's/system's fit, form, and function is received from:

- Senior Management (varying opinions and level of authority)
- D&R engineer (personal beliefs based on experiences and own values)
- Government Regulations (ex. FMVSS 201 – Vehicle Crash Requirements, etc.)
- Government Organizations (ex. NHTSA)
- Automotive News media (ex. Motor Trend, Consumer Reports, etc.)
- Consumer Organizations (ex. Consumer Reports, etc.)
- Insurance Industry (ex. Insurance Safety Institute, etc.)

Chapter 3: Market Research Overview

The costs for market research (MR) in the automotive industry are seemingly dwarfed by the millions of dollars spent to develop entirely new automobiles or make product revisions (ex modifications to add a new car door). Properly applied, as in the case of Chrysler's introduction of a driver-side sliding door, MR is intended to reduce financial risk during the development of automobiles. The purpose of this chapter is to provide a brief overview of MR and methods, OEM-A's formal MR process, and the informal MR practice at OEM-A. Research methodology and results will be presented in Chapter 4.

Overview of Market Research and Methods

"Defining Market Research"

E. McQuarrie [31] defines MR as "any effort to gather information about markets or customers." He also generalizes that the need for MR increases as the measure of market uncertainty increases. Increases in market uncertainty could be caused by changes in market size, economic conditions, competition, and technology. In addition to those stated by McQuarrie, other factors can increase uncertainty such as shifts in customer preferences (ex minivans vs. station wagons), executives' understanding of customers, and representation of target customer demographics with the membership of program team.

Grossnickle/Raskin [32] differentiate between two major categories of customer-related research: MR and market intelligence (defined by McQuarrie as secondary research). MR has a finite start and finish. In contrast, market intelligence is often

conducted on an ongoing basis and may not be directly linked to a particular product development effort or research investigation. MR into a specific research problem is conducted after exhausting the limitations and usefulness of market intelligence. Both types of customer research, market and intelligence, are utilized during a product development effort.

According to McQuarrie, MR can be applied for "exploration" or for "confirmation." For exploration, a company uses MR to develop business and product opportunities (i.e. expand the organizations perspective) and then develops strategies to make them a reality. For confirmation, a company uses MR to help select optimum alternatives (i.e. product assumptions) and confirm the ability to deliver the business opportunity. In some instances, the company forgoes exploratory research and relies instead on internally developed business and product opportunities prior to conducting confirmatory MR. Based on observation and input to be presented from research respondents, OEM-A tends to utilize MR as a strategy confirmation. Subsequent chapters will discuss the issues that arise when MR confirmation is paired with the competitive pressures of timely development execution.

Exploratory and confirmatory MR is typically facilitated using qualitative and quantitative methods respectively [32]. Qualitative research methods, such as interviews and focus groups, are intended to initiate direct interaction with respondents. Conversely, quantitative research methods, such as surveys, are intended to focus on data reliability using statistical methods. The qualitative results are viewed as necessary inputs before executing quantitative results. Without qualitative input, the validity of the qualitative

survey to the entire population being studied is less certain. The limitations in respondent response in a quantitative survey are mitigated using qualitative research.

The methods used in qualitative and quantitative research vary. For example, qualitative methods such as *ideation* utilizes respondents to develop creative ideas while *concept testing* methods may help a program team to decide which concepts to further develop. Similarly, quantitative methods such as *interviewing* could be used to select among options while a *survey* could be used to evaluate the success of a new product.

Manufacturers, like OEM-A, utilize contractors to assist in conducting MR. However, the product developers maintain MR competence in order to define the research problem and to interpret/utilize research results. The strength of a product development company in using MR is influenced by the ability to appropriately define the problem and select the appropriate method at the appropriate time. The problem definition should rely heavily on the program-team's input, as the goal is to reduce their uncertainty. The MR activity is responsible for selecting the appropriate MR methods. For example, the results of qualitative interviews will help define the set of questions that when answered quantitatively by respondents should confirm effective product decisions.

"Available Market Research Methods"

This section will provide a brief description of some of the MR methods that may have application during the automotive product development process. The format follows from that described by McQuarrie [31] where market research tools are divided into six categories: secondary research, customer visits, focus groups, survey research, choice models, and experiments. The descriptions, unless otherwise noted, are

referenced from Dahan/Hauser [33]. The following paragraphs will provide a brief description of each category and examples of related methods:

Secondary Research = "...any data [qualitative or quantitative] collected by someone else for some other purpose, which also happens to be useful to you." [31]

- J.D. Power Quality Study: An independent market research firm, which markets the results of customer satisfaction and product reliability for new automobiles.
- Consumer Reports: An independent consumer agency that subjectively and objectively rates automobiles for competitive comparison.
- Internal Quality Surveys: Similar to J.D. Power but conducted by the manufacturer.

Customer Visits = One-on-one interviews conducted in the customer's environment to develop qualitative customer data

- Experiential Interviews: Interviews conducted with a single customer, preferably in their natural environment, to determine the underlying issues that the customer needs to solve.
- Empathic Design: Members of the program team observe and imitate customers in the customer's environment to gain understanding of needs that are difficult to articulate.
- Lead Users: Identify and interview users, likely in unrelated fields, where their needs significantly outweigh those of the product being studied. These lead users

are then involved in applying their innovative solutions in the development of new product concepts. Founded on the adage that "necessity is the mother of invention."

- Metaphor Collage: Customer uses pictures obtained from magazines and newspapers to express feelings and attitudes.

Focus Groups = A professional moderates a predetermined discussion with a group of 8 to 12 target customers to develop qualitative customer data

- Customer Advisory Boards: A standing group of external customers or company employees provide product suggestions and concept/design evaluations throughout the product development execution [34].
- Information Pump: The quality of an individual's input regarding a proposed concept is judged by a virtual focus group to determine financial incentives

Survey Research = Customers, representing those being targeted, answer a fixed set of questions to develop quantitative data to support decision making

Choice Models = Customers choose between product attributes that when analyzed quantitatively will determine the relative degree of influence on purchase decision or customer satisfaction

- Conjoint Analysis: Need/concept prioritization based on customer's tradeoff
- Voice of the Customer: Statistical analysis of need statements, sorted by customers, determine relative importance of groupings

- Securities Trading of Concepts: Concepts are traded among a group of customers like securities to determine top performers
- User Design: Customer configures product from a set of options while evaluating the resulting function/price status
- Internet-Based Rapid Concept Testing: Customer purchases virtually depicted concepts at varying prices
- Kano Model: Product features, mapped from customer needs, are categorized [33] by strength of relationship between their performance and customer satisfaction (CS). Features will move to a weaker relationship as time progresses. Performance is measured relative to competitive vehicle set. Each of the three categories use the following generic relationships between feature performance and CS:
  - *Must Have*: any performance increase will result in a small increase in CS while a performance decrease will result in a large decrease in CS
  - *More the Better*: a performance increases or decreases will have a corresponding effect on CS
  - *Delighter*: a performance increase will have multiplied effect on CS

Experiments = Customer preference among limited options is quantitatively defined

- Listening In: A passive analytical observation of a customer's online search/purchase behavior to identify un-met customer needs

Market Research at OEM-A

"Participating Organizations"

The market research activity at OEM-A will be referred to as Market Research Activity (MRA). MRA is an organizational member of the Marketing and Brand Management organization. The primary responsibility of MRA is to recommend, plan, and conduct MR for developing consumer insights. In practice, MRA works collaboratively with the marketing activities that are often referred to as the "voice of the customer" on the program teams they support. In OEM-A's North American operations, MRA typically will assign a MRA representative as a "member" of each program team. Some MRA representatives may support more than one program's needs regarding MR.

Although MRA requires certain research events to be conducted on substantially new programs, there are no formal mechanisms within the PDP to force compliance by the program teams. In most instances, MRA cannot conduct MR without the program team supplying product information (ex. vehicle illustrations, full-scale fiberglass properties, physical properties, etc.). As a result, the type and timing of MR can vary between programs including those that are similar in degree of product change.

MRA is working to improve their ability to support the product development in a timely and cost effective fashion. For example, some amount of MR is being conducted using the Internet to better support timely program decisions. In addition, MRA has recently completed a highly successful program where program teams were exposed to their targeted customers including drive evaluations. Surveys of program teams indicate the initiative was successful in helping employees seek customer involvement throughout the product development process.

"OEM-A's Formal Market Research Process"

MRA has formally defined a MR process, which is published on a company Intranet web page. Most of the formal MR processes are integrated into OEM-A's PDP. The purpose of this section is to generalize the major MR events that are conducted in support of product engineering. As a result, some MR events are omitted such as those relating to sales communications. The research will be described as the program passes through the phases of product development: pre-program, define, design, verify, and launch. Unless otherwise noted, all formal MR events are conducted using respondents recruited from outside of the company.

In the ***pre-program phase*** of OEM-A's product development, a detailed product proposal is being developed without a formal program team. Instead, members of OEM-A's business office and advanced engineering activities are working to develop a product proposal. Frequently, product programs are based on an existing vehicle. In that case, the existing program chief engineer and other program managers will serve as surrogate consultants until an official program team has been formed. The pre-program phase consists of the following MR actions:

- Research Review: consists of a comprehensive gathering of all existing MR and market intelligence documentation including MR and market intelligence. The market intelligence data consists of items such as ongoing customer satisfaction and quality surveys, competitive product evaluations, brand strategy research and advanced features research.

- Futuring (quantitative): the intent is to utilize social trends to estimate or future the existing MR conclusions (especially customer needs/wants) to the anticipated production timing of the new product.
- Market Research Plan: the MRA activity will meet with members of the program team to determine an appropriate plan of MR based on the available product assumptions and the needs of the program-team members.

In the ***define phase*** of OEM-A's product development, detailed product proposals and strategies are being developed that satisfies an acceptable business equation. The primary purpose of this phase is to define "how" the vehicle is supposed to perform and the high-level vision of "what" actions will be taken to make the vehicle performance a reality. The following MR actions are made during this phase:

- Customer Emersion (qualitative): the program team, which typically has yet to be staffed by design and release engineers, is provided with the opportunity to meet the targeted customer(s), observe their lifestyle/values, and learn about their vehicle usage/needs.
- Visualization Research (qualitative): the styling studio is provided with collages developed by target customers that emulate their desires for the products appearance.
- Attribute Prioritization and Target Setting (qualitative): the program team is assisted in developing vehicle attribute priorities and in setting key functional targets such as interior package (ex. headroom) and vehicle dynamics (ex. ride and handling performance).

- Feature Availability (quantitative): determine the optimum availability and grouping of standard and optional product features for each major market (ex. USA, Japan, Europe, etc.).

In the ***design phase*** of OEM-A's product development, the results of the definition phase are being applied to create detailed product assumptions and designs. The following MR actions are made in direct support of the design phase:

- Styling Development (qualitative): customers interact with studio members to influence styling development.
- Package, Proportions and Theme (qualitative / quantitative): assess customer acceptance of the proposed interior package, vehicle proportions and the alternatives for interior/exterior styling themes. May include separate evaluations conducted by company employees.

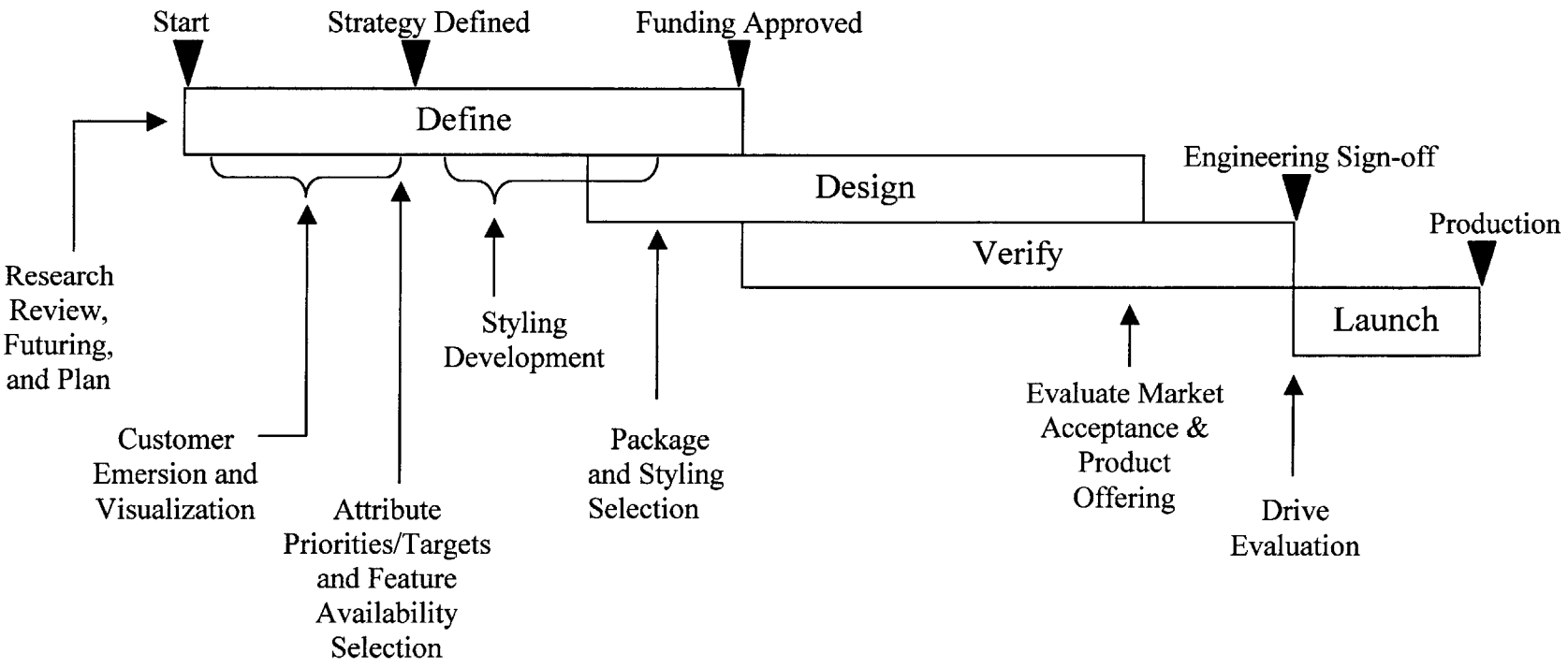
In the ***verification phase*** of OEM-A's product development, the results of the design phase are "verified" versus customer, regulatory, and company requirements established in the "define" phase. The following MR actions are made in direct support of the design phase:

- Market Acceptance & Product Positioning (qualitative / quantitative): to determine customer's acceptance of the product, features, and pricing using prototype vehicles and competitive products

In the ***launch phase*** of OEM-A's product development, the results of the previous phases (pre-program, define, design, verify) are confirmed before beginning mass production. The following MR actions are made in direct support of the design phase:

- Drive Evaluation (qualitative / quantitative): customer evaluation of pre-production units (i.e. vehicles assembled from production tooled components) to confirm attainment of attribute priorities before launch. May include respondents from product engineering.

Figure 3.1 Generalization of OEM-A's Market Research Process Related to Product Engineering



"Informal Market Research"

In addition to the formal MR conducted by the MRA, additional informal or "as-required" MR is conducted in support of product development. The informal MR is often developed and executed by various engineering organizations such as product design, styling, occupant package, and quality. Based on the author's evaluation/participation in numerous informal research events, interviews of informal MR initiators, and discussions with MRA representatives, it is unlikely that MRA provides significant input to developing and executing informal MR.

It is common to receive E-mail (i.e. at least one per week) from activities within OEM-A (N.A.) that are looking for some type of "customer" input. During the preparation of this thesis (approximately 10 months), the author collected a significant amount of intra-company emails and employee experiences relating to informal MR. Although the average response rate and survey length is unknown, it is likely that the surveying costs (of informal MR) are significant.

For example, one of the quantitative Intranet surveys was conducted to investigate the styling preference for a floor-mounted shifter knob used to toggle between the gears of a manual transmission. According to the survey author, more than 13,000 responses were received from within OEM-A. Estimating a survey completion time of 5 minutes and a wage rate of $50 per hour, the execution of the informal for this particular event is likely to have cost more than $54,000.

The significant volume of informal MR may be indicative of the potential for improvements in the formal MR plan. The informal research can be grouped into five basic types with the *observed* occurrences shown in parenthesis:

A. Quantitative/Qualitative Intranet surveys (total of 20)
B. Quantitative Internet Surveys (total of 6)
C. Static product evaluations (total of 19)
D. Vehicle Drive Evaluations (total of 2)
E. Customer "Advisory" Boards (total of 3)
F. E-mail Requests to Evaluate Customer's Vehicle (total of 23)

"Quantitative/Qualitative Intranet surveys"

With all salaried employees of OEM-A having access to E-mail and the Intranet, quantitative/qualitative Intranet surveys have become extremely popular at OEM-A. Notification regarding the availability of an Intranet survey is easily made via email distribution lists to a large population of employees such as "*All North American employees.*" Some surveys requested respondent demographic data and while others may have requested participation only from customers of a certain product type. The content of these surveys varied considerably. For example, some Intranet surveys provided pictures (ex. transmission shifter designs) or virtual representations (ex. cargo storage devices) while others were limited to text. A large number of the Intranet surveys were created with the assistance of a design and release engineer who happens to have knowledge of Web programming. Without the assistance of MRA, this individual created a simple web site and tutorial to help anyone interested in completing an Intranet survey. The purposes cited for conducting the informal research (with examples) were as follows:

- *Determine customer utilization rates and environment*: Example – determine how often customers utilize the interior lights of their automobiles
- *Issue investigation*: Example – determine location and frequency of dents and dings in body sheet metal and how customers use their automobiles

- *Selection amongst design alternatives*: Example – selection of design options for customers to close a liftgate (i.e. hanging strap versus a pull handle)
- *Feature awareness*: Example – quantify the customer's understanding of the function of the key fob (a remote device that locks and unlocks doors/trunks)
- *Rating the performance of current products*: Example – determine the effectiveness of the rear window defroster for a specific model

The author found many potential issues with the Intranet surveys. A significant number of surveys, some of which were completed by thousands of respondents, did not ask for respondent demographics or provide the ability to sort data on respondent type. In addition, most of the surveys written used engineering terminology that might not be familiar to all respondents. For example, an Intranet survey on exterior molding asked respondents if they had an issue with their "belt molding" on a specific vehicle; certainly some respondents would not know that this molding was located at the bottom of the window glass in each passenger door. The same survey had a significant number of questions that would likely have required the respondent to view their automobile before completing the survey. Other issues included poor resolution of photos and excessively long surveys.

Discussions with some of the survey creators revealed a varied experience with the benefits provided by the survey. For example, a transmission shifter-knob survey was created to challenge a styling decision made by the program managers of a specific program team. The results received from 13,000+ respondents indicated an overwhelming preference for the design not selected by the program managers. However, one of the program managers disputed the validity of the survey results. In

another case, a survey was created to test the preference for the type of ashtray design. The survey creator obtained data that provided new information regarding the customer's usage and heavily influenced the design selection.

"Quantitative Internet Surveys"

Informal Internet surveys conducted using non-company employees were less frequent than the informal Intranet surveys. Internet surveys were similar to Intranet surveys except that they had higher quality web programming. The explanation for the improved graphical interface came from the significant investment (over one million dollars according to a member of the development team) paid to contract with a major software developer. A single program team planned and funded the creation of the Internet survey tool (i.e. software). The consultant developed the software to allow program engineers to create their own surveys without significant training. A member of the development team, who had created the survey tool on an "unofficial basis," confirmed that MRA had not participated in the software development.

The idea to develop the Internet tool came from the desire of this particular program team to better understand which design actions would improve customer satisfaction. Specifically, the program team felt is currently the case, data provided by MRA regarding current customer satisfaction provided inadequate resolution to support decision-making. OEM-A uses sixty-six questions to survey their customers months and years after their vehicle purchase. Program teams are given targets to improve the performance of both overall customer satisfaction and that of each individual question. For example, one of the satisfaction questions asks customers how satisfied they are with

the "ride comfort" of their vehicle. This data did not provide the program team with enough information to determine the source of the customer's satisfaction. Using the Internet survey, they were able to determine that a large number of their customers viewed "ride comfort" as the comfort provided by the vehicles heating and cooling systems. In addition, they were able to learn more specifics of how customers liked or disliked the ride and handling provided by the vehicles chassis (i.e. suspension and steering). The survey developers felt that they were able to make better decisions in less time. For example, an investment of $180,000 dollars was saved when the majority of customers declined a planned program feature that was not evaluated in formal MR.

The developers were pleased with the results provided by the Internet survey tool. However, they were disappointed that in some instances, senior management made decisions that were contrary to survey results. For example, a product planned for the German market utilized the survey tool to obtain customer preference for seating fabrics in three days. The survey results showed that German customers prefer the availability of a dark interior seating fabric. Unfortunately, a decision was made to not offer a dark colored seat fabric. It was unclear as to what other factors may have influenced this decision (i.e. cost, complexity, studio preference, management preference, etc.). Although the program team was disappointed with the decision, the availability of customer data provided a basis for discussion and a hope for future debate.

The Internet survey tool was developed to allow engineers to avoid surveying employees. Specifically, an agency was hired to recruit "club" of customers who matched the demographics of the targeted customer. Members of the customer club earn

points for each survey they complete. Points can be redeemed for merchandise valued at less than $30 dollars.

A formal process was developed to allow program members to survey the customer club. First, the program member would propose a question to the customer club on the "forum" to obtain qualitative data. Second, the program member would use the qualitative data to develop a survey proposal. A committee of program members would review the program members' proposal and makes suggestions, if necessary, before formally developing the Internet survey.

"Static product evaluations"

Static product evaluations, which rivaled the frequency of Intranet surveys, were conducted by various engineering activities. Often, the purpose of the evaluation was to obtain "customer" feedback regarding a new design. The scope of the evaluations ranged from the entry and exit to the third row seat in a SUV to the evaluation of seat belt function. In one instance, the product evaluation was conducted to evaluate customer preference for the rear closure of a vehicle (hatchback, lift gate, or deck lid). E-mail notices were used to notify building occupants of an upcoming evaluation. Coffee and donuts were usually provided to promote participation. One of the more unusual product evaluations had respondents use their gloves and mittens to function instrument panel controls. Evaluations were generally open to all employees. However, a hands free cellular phone evaluation required interested respondents to first complete a demographic profile prior to being selected for hardware evaluation.

"Vehicle Drive Evaluations"

Vehicle drive evaluations were conducted to evaluate the vehicles functional performance. It was common for programs to recruit respondents directly from the program team. This practice may have been the result of the length of drive evaluations (one to two hours) required of respondents. Some evaluations tried to recruit respondents that represented the varying demographics of the targeted customer.

One program utilized non-employees to evaluate product proposals. In this case, the program provided customers of competitive products with their product for a two-week period. Respondents were required to spend an hour with members of the program team comparing and contrasting the two vehicles. Program team members felt a significant benefit was received from these discussions. The same program team also interviewed customers that were returning specific vehicles to car rental companies.

"Customer Advisory Boards"

Customer advisory boards (CAB) are beginning to become more popular at OEM-A (program specific and customer specific such as the Women's CAB). The practice and composition of the various CABs at OEM-A vary considerably. A CAB is a collection of customers that is used by a program to obtain customer "advice" regarding the identification of current product issues, the evaluation of design improvements, or the evaluation of new concepts. . For example, "Team-X" at OEM-A recruits product customers that live near the engineering facility to serve as members of the CAB. The quality supervisor manages the Team-X CAB. Team-X conducts sessions, preferably on a quarterly basis, where customers evaluate both product improvements and new product

concepts. Customers are provided with an inexpensive gift in appreciation for their participation. According to the Team-X CAB leader, the use of a CAB has significantly influenced decisions regarding the following items: engine and transmission offerings, improving seat comfort, cup holder design, improving the ease of rear seat folding, and delaying the introduction of a new feature. Once prototypes are available, the use of the CAB was expected to ensure that the re-design solves the customer's concern.

Although the CAB has been beneficial to Team-X, it has not been without issue. The leader of the CAB indicated that there is a continuous struggle with product engineers to look outside of their own experiences. In addition, although the product engineers support customer involvement, they have become accustomed to relying on their own perspective to make decisions. Funding is another challenge to conducting the CAB, as it is not covered by the MR budget. As a result, to the extent of informal MR on Team-X was limited.

Based on the author's participation in a Team-X CAB event, the execution of the CAB is not without issue. Respondents in a recent Team-X CAB were asked to evaluate improvements in the seat cushion after only a few seconds of sitting in the seat. In addition, while sitting in the driver seat, respondents were asked to rate the improvement in lighting for rear seat passengers. The author's facilitator failed to explain the meaning of the 1-10 rating scale other than that higher was better. For example, a good, bad, neutral rating may have been easier for customers to utilize. Lastly, concept drawings of a cargo management system did not come with any explanation of assumptions (removable? adjustable? Etc.).

"E-mail Requests to Evaluate Employee's Vehicle"

It may be debatable whether requests to evaluate a customer's vehicle are considered MR. However, this type of evaluation can indirectly measure the customer's identification of what was or wasn't a problem. For example, one such request asked owners of a certain product to respond if they had wear issues with their seat fabric. Other requests asked to evaluate owners of specific vehicles that were exhibiting items such as noisy brakes or poor engine idle. It is unlikely that the requestors of this type of survey considered the potential for selection and non-response bias in respondents. However, it is more likely that the requestors were looking to resolve specific issues identified by statistical warranty data.

Often, these numerous vehicle evaluation requests are limited to a certain model and year. This makes a majority of these notices of little use to the majority of recipients. With the thousands of OEM-A employees, a better method may exist to direct evaluation requests to the owners of the targeted model.

The evaluations of employee vehicles are usually directed toward obtaining physical data regarding a product reliability (performance over time) issue to numerical warranty data. In one case, the interior trim design activity wanted to view the performance of the metal retainers used to hold the plastic door trim to the door structure. Many of the product evaluations attempted to utilize qualitative surveys to document the performance of the new design proposal as compared to the current design and/or competitive vehicles.

"Chapter Summary"

The following items are summarized from this chapter:

1. Market research is conducted to obtain information about customers to assist in developing new products and reducing the uncertainty of a products performance in the marketplace.
2. Market research is conducted in support of a particular product development while market intelligence is conducted on an ongoing basis.
3. Market research methods can be divided into secondary research, customer visits, focus groups, surveys, choice models, and experiments.
4. OEM-A utilizes a formal market research process during each phase of the product development process (define, design, verify, and launch).
5. The following types of informal market research are utilized by program engineers in support of product development: Intranet/Intranet surveys, static product evaluations, vehicle drive evaluations, customer advisory boards, and E-mail requests to evaluate an employee's personal vehicle.

Chapter 4: Research Results

Research was conducted into the product development practice of OEM-A's North American product development operations. The focus of the research was to determine if the product developers at OEM-A feel isolated from the voice of the targeted customer (VOC) and if so, why. The following items will be presented in this chapter:

- Research Methodology
- Research Results
- Needs Summary

Research Methodology

The qualitative research conducted in support of this thesis consisted of fifteen one-on-one interviews with members from the following OEM-A's North American activities:

- Program Team Engineers, Supervisors, and Managers
- Styling Managers
- Market Research Managers
- Marketing Managers

In addition to being members of one of the above activities, respondents were selected based on the following characteristics:

- Responsibilities included a high degree of customer interaction (ex. instrument panel, fuel system, etc.)
- Responsibilities supported engineering work for product development (vs. advanced engineering)

Interviews were completed for all requested respondents. None of the respondents declined an interview. Therefore, it is unlikely there was self-selection bias. The interviews were conducted at each respondent's desk and lasted for approximately one hour. Respondents were told the purpose of the interview was to discuss their view of customer involvement in the OEM-A product development process. They were then asked to respond to a series of questions (see Figure 4.1) and given an opportunity to provide unsolicited input.

Figure 4.1: Primary Interview Questions

- What are the demographics and lifestyles of your target customer?
- What are the customer-driven requirements/needs of the product you design or manage?
- How do you determine which needs are important?
- How do you use customer input?
- What are your needs for gaining access to customer input during the PD process?
- Is there anything that prevents you from obtaining customer needs? If yes, why does it exist?
- What tools do you use or would like to have available relating to obtaining customer input during the product development process?

Summaries contained in this chapter were developed from the interview data. It is necessary for future research to be conducted in response to this thesis in order to develop the statistical data required for certainty statements regarding the various organizations within OEM-A.

Research Results by Activity

In general, most respondents were happy the topic of customer integration into PD was being pursued. The members of the program team (both management and engineers) were the most enthusiastic about the need to change the current practice towards customer involvement in PD. Although MRA and marketing respondents acknowledged issues with the program team's access to customers, they were generally less enthusiastic that anything constructive could and/or should be done to improve the situation.

Although most respondents were willing to provide their input, design and release engineers generally seemed less comfortable at the beginning of the interview. The source of their discomfort may have come from the consistently poor level of customer interaction as evaluated by the D&R engineers themselves. A measure of discomfort is to be expected when one considers the work of the D&R engineer is continually being evaluated for accuracy and completeness. To help improve feedback from D&R engineers, the author expressed that the interview was not intended to grade their performance and that it was unlikely they were alone in their experiences. This section will cover research results from the following work groups:

- Program Managers
- Program Engineers
- Styling Managers
- Market Research and Marketing Managers

"The Perspective of Program Managers"

Managers from the program team, referred here as "Program Managers," indicated they were disappointed with the current level of customer interaction during the product development process. For example, one program manager was amazed that she had not interacted with the targeted customers of the product since was preparing for production. She had joined this particular program team one year earlier.

On a prior program, she had a positive experience as a market-research participant. In that formal MR, she had interviewed customers while they were using their personal vehicles. In that case, the research results significantly influenced revisions to the product assumptions.

Program managers identified four factors that influence the current deficiencies in customer involvement:

1. Hierarchical decision making
2. Hypersensitivity to vehicle functional performance
3. Minimal autonomy in conducting/directing MR
4. Timing of MR events not aligned with product development

1. Hierarchical decision making:

This group of respondents shared a common struggle in trying to balance input, often received late in the program, from various senior executives. In this case, senior executives include those managers with a reporting relationship above the program's chief engineer. The respondents agreed that the program team often view senior executives as the "real customers" of the product development effort. The input received from various senior executives tends to prioritize multiple vehicle attributes as the

"number one" priority. For example, a respondent cited a case where one executive championed leadership in safety, vehicle acceleration, and interior occupant space while another executive championed vehicle handling and excellence in the fit between body (interior and exterior) components.

With many successful vehicles leading their competitive segment in only one or two vehicle attributes, it was easy for these respondents to understand how OEM-A's program teams have difficulty in making tradeoffs. Tradeoffs between vehicle attributes are necessary due to limited financial and engineering resources. One respondent indicated, "the attribute tradeoff process usually involves the program's chief engineer and marketing manager versus senior executives." The unresolved conflicts in attribute priorities remaining after strategic definition tend to cause oscillations in design direction. The oscillations tend to stabilize late in the PD process when engineers are supposed to be verifying the capability of their product-intent designs.

To further compound the issue, some respondents felt that each executive may have a different view of how a vehicle demonstrates "leadership" performance. In some cases, the input received from senior management is based on their personal experience (or perhaps that of a neighbor/friend). One respondent cited a case where the son of a senior executive had his spare tire stolen twice from his SUV. These events prompted immediate action -- cascaded down through the management chain-- to improve the design of the spare-tire stowage.

One respondent indicated that program teams have learned how to manage input from executives. For example, one program team conducted separate drive evaluations with two executives who are known to champion ride and handling performance. Using

input from the two separate drive evaluations, they identified the common elements between the executives and highlighted these in a joint drive evaluation.

According to one respondent, the program team members typically know when an executive decision is made that will be bad for the customer but are often left with little choice but to implement the executive decision. For example, the same respondent cited an experience during a sign-off drive (prior to production release) when a senior executive expressed negative comments concerning the location of the interior door handle (front seat positions). The executive, who felt the handle was located too low and forward in the vehicle, could not believe that such a mistake could be made. The respondent knew the handle location had been selected by one of the studio (styling) executives who "*probably never sat in the seating buck* [used to evaluate interior ergonomics]." The respondent went on to add that…

> "*Everyone on the program knew it* [the door handle] *was in a bad position but there was nothing they could do about it.*"

Unfortunately, any design revision would have to wait until the next interior freshening scheduled for many years later.

2. Hypersensitivity to vehicle functional performance:

One respondent felt that experts in vehicle attributes such as ride and handling or NVH (noise, vibration and harshness) tend to lose their ability to objectively view the value of attribute performance from the perspective of the customer. The same respondent cited a case where an executive questioned the value customers would assign to noise reductions gained from the release of a revised engine component. The

executive was sure that he and the NVH experts could tell that the new engine component, costing $25 more than the carryover part, was much quieter. Unfortunately, the executive was uncertain as to how much the customer would actually value the improvement. It was unlikely the resolution of the ongoing satisfaction surveys (ex. "how satisfied are you with the interior noise level?") would provide a high degree of certainty in answering the executive's question. Based on discussions with the NVH engineers, customers (internal or external) did not evaluate the proposed change before production release.

Another respondent cited a case where significant management attention was given to the consistency of gap between the engine hood and the front fenders of a new vehicle. In this case, the program manager verbalized an opinion that the majority of the targeted customers did not really care as much about the gap consistency as did the senior executives.

3. Minimal autonomy in conducting/directing market research:

Some respondents indicated a lack of independence or autonomy from the MR activity. The respondents expressed a desire to obtain MR that supported timely decision-making and that was not subjected to significant interpretation from the marketing activities before publication. Respondents felt they were capable of interacting directly with customers. They viewed the current MRA capabilities and interests to be tailored towards large MR events that were both costly and time consuming.

Respondents preferred that tools be made available to allow the program team to conduct MR with a more limited scope. For example, one program team needed to select

the type of interior floor carpet for their new vehicle. The program team had to decide between different grades of carpet that varied in cost ($). At the request of the program's chief engineer, an informal gathering of approximately ten team members was held to determine which carpet should be selected. The panel's decision to use the more expensive carpet was well received by both dealers and customers. In this case, many of the team members were owners of the current model of the product they were developing. Had this not been the case, dealers and customers might not have been as supportive of the team's decision.

The examples provided regarding hood-to-body gap consistency and the selection of interior carpet illustrate the importance of relying on input from the target customer to drive decision-making. It is important to understand the purpose and limitations of market research techniques and to ensure proper and timely application.

4. Timing of market research events not aligned with product development:

The fourth factor that limits customer interaction during product development is the misalignment in the timing of MR events and the PD process. For example, the formal MR to expose team members to customers is done at a point (prior to strategy definition) when the program staffing, per the formal PD process, is minimal (<10%). The timing misalignment can create a situation where few of the program team members are exposed directly to the target customer. Frequent changes in program team members throughout a three to four-year product development may worsen this situation.

One respondent expressed the view that many program-team members "lose sight of customers" due to a lack of interaction with customers. In addition, the respondent

sometimes felt that he was the only one on the program asking the types of questions a customer would ask. For example, a design proposal was made for a new roof rack with functionality beyond that which was typical for this particular vehicle. The engineers and suppliers were hoping to receive approval to proceed with production designs. The respondent was disappointed that he had to point out items that, in his opinion, would create dissatisfaction in customers. One such item was the tendency of the roof rack to create significant scratches in the paint during loading/unloading.

"The Perspective of Program Engineers"

The program engineers are involved in designing subsystems/components and performing development testing. Considering all research respondents, the program engineers seemed to be the most isolated from customer interaction. Although aware of the absence of customer input, their focus was placed primarily on the following items: package compatibility, minimizing piece cost, supporting vehicle builds with prototype parts, and demonstrating function as described in the system design specifications. Program engineers identified three factors that influence the current deficiencies in customer involvement:

1. Lack of system design engineers
2. Engineering phases not adequately covered by the formal market research process
3. Reliance on formal documentation of system design specifications

1. Lack of system design engineers:

OEM-A distributes design and release responsibilities primarily on a component basis. For example, a new feature like a power-activated minivan lift gate would typically assign a different engineer to the following lift-gate components: sheet metal,

glass, power actuators/linkages, interior trim, exterior trim, wiring/lighting, and handles/locks. At OEM-A, engineers are grouped by commodities. For example, the sheet-metal engineer would be a part of the closures sheet metal group and the engineer for power actuators/linkages would be a member of the electrical group. One respondent from program engineering was uncertain as to who would evaluate the customer's perspective of the system their components helped to comprise. Another respondent indicated the vehicle test engineers would be responsible for evaluating the customer's perspective. In general, engineering respondents had difficulty identifying an individual responsible for evaluating the system's performance.

2. Engineering phases not adequately covered by the formal market research process:

The respondents had favorable experiences with a MRA initiative to expose program teams to direct contact with their targeted customers (mentioned in Chapter 3). This event facilitated the interaction of an entire program team with their current customers in a full-day offsite (non-reoccurring). However, the respondents felt that more customer exposure was necessary to help support specific feature concepts and design execution.

Many of these respondents did not know which activity provided MR support and further that there existed a formal process for MR throughout the PD process. In addition, none of the respondents who knew that MRA existed were aware that support was available to them to conduct MR. The lack of formality in customer evaluation provided challenges for engineers who had system design specifications (SDS) requirements that called for a jury evaluation. For example, the vehicle jacking and spare

tire engineer (a respondent) was required to perform a subjective jury evaluation of his system as a confirmation of the adequacy of his designs. This respondent, who had a basic idea of the target customer's identity, had not interacted with customers since joining the program team two years earlier. Unfortunately, the respondent was unable to obtain a Phase-One prototype vehicle (out of two prototype phases) to perform an evaluation of his designs. This situation troubled the respondent. Having to wait until Phase-Two testing to confirm the adequacy of his system would make engineering revisions more difficult to execute.

Issues, as defined from a customer's perspective, that are discovered late in the development process may be labeled as "discretionary" changes that may or may not be completed. Based on respondent experience, product evaluations published in magazines such as *Consumer Reports* tend to be harder to discount, due to the millions of readers who are potential customers.

Dealers, who are independent distributors of OEM-A's products, are also mentioned by respondents as being excluded from the product development process. Dealers typically accumulate a great deal of informal customer feedback. Dealer input is supposed to be channeled through the marketing organization and then provided to the program team. One respondent indicated that his program had established a limited degree of direct interface with an OEM-A dealer. Although unquantified in degree, dealers can and do provide valuable customer feedback. For example, a respondent described how a program team was able to utilize a supplier's contact with OEM-A dealers to learn that customers of an OEM-A product wanted body-colored running boards and larger wheels/tires on the middle trim series. Using this information, a limited

edition model was created that was both profitable for OEM-A and highly desired by dealers and their customers alike.

3. Reliance on formal documentation of system design specifications (SDS):

The design and release engineers utilize the SDS to guide the design and verification requirements of their components and subsystems. OEM-A uses a database of engineering specifications and product requirements that number in the thousands. Although an unquantified number of customer requirements are included in the database, respondents indicated (confirmed by the author) there is currently no method available to locate requirements originating from customers. If there is some question or debate regarding the validity of the SDS requirement, the engineers may often rely on the program's chief engineer to make a ruling. Deviations from the SDS are required to be documented and approved by senior management. With thousands of requirements to satisfy, the program team struggles to perform multi-variable optimizations. Although viewed as being valuable, some of the respondents (program engineers) were not planning to conduct a customer evaluation of their components/subsystems. Instead, their goal was to ensure their designs satisfied the SDS requirements.

For example, the fuel system supervisor of a new product described how the SDS limits the angle and height of the fuel door. To prevent the metal fuel door from having a complex surface, the styling studio determined a door location that provided the same (relatively flat) fuel-door surface for all body configurations. Unfortunately, the resulting fuel-door height and associated fill angle was higher than that allowed by the SDS specification. A review was conducted with the program's chief engineer around a fixture

that allowed the fuel door height and angle to be varied to maximum values allowed by the specification and to the height proposed by the studio. The program's chief engineer decided to approve the request based on his evaluation of the fixture and the fact that another OEM-A product had a comparable fuel door height and fill angle. This respondent felt that it was much easier to submit an engineering deviation than to attempt the improbable task of changing the SDS requirement. In this example, a timely decision was necessary to allow work to proceed. However, confirmation of the accuracy of the decision will not be made from a customer perspective until the product is months from mass production. At that point in the development process, any internally generated complaints may tend to be discounted due to the cost and time required to execute design revisions.

"Styling Manager's Perspective"

The styling managers are responsible for executing the appearance-related aspects of the vehicle exterior and interior. The output of their effort (computer data that defines the various interior and exterior surfaces) is used by the program teams to create detailed component designs. Using a combination of computer guided milling machines and clay modelers (the human kind), clay models are used to develop the interior and exterior styling themes. According to the formal MR process (see Chapter 3), the studio utilizes market-research input to assist stylists early in the styling development and to confirm the styling theme.

One respondent indicated he received adequate support from MRA (regarding target customer identity and customer prepared imagery) to conduct his job functions. In

addition, the respondent felt customers participating in market research could provide valuable input regarding a vehicle's styling that was 1-2 years from production release.

Respondent comments regarding customer involvement during the styling process centered on the following areas:

1. Early customer input prior to beginning styling process
2. Managing input from program, studio, senior executives, and everyone else

1. Early customer input prior to beginning styling development

The studio respondents indicated a preference for customer input early in the styling development. Specifically, qualitative input was more valued than the quantitative evaluation of clay properties. Respondents also indicated that product development schedules do not allow much time to wait for MR results. The time pressures are due to the long lead times required to produce production tooling for exterior body components and interior instrument panels.

2. Managing input from the program, studio, and senior executives

Like the program managers, the studio is forced to balance the numerous opinions expressed by program managers, studio executives, and other senior executives. One respondent felt that "senior executives serve as the voice of the customer." In addition, input provided by senior executives can be received after the selection of the styling theme when manufacturing feasibility is the primary focus. In the respondent's experience, "the change usually happens anyways."

The same respondent cited an example of the challenge presented by a senior member of the Women's Marketing Organization (WMO). The purpose of the WMO is

to provide input into current and future product development from a women's perspective. The WMO leaders were promoting a style for a new sports car that was similar to other OEM-A cars known for having "feminine" styling. The heritage of this particular sports car had a well-established reputation for its masculinity. With a significant number of female customers purchasing this product, the WMO had a significant advantage point. The studio, however, contended the new styling should continue to maintain a masculine image. The studio respondent felt that women purchase this particular product because it allows them to obtain the powerful image associated with the masculine design.

"Market Research and Marketing Manager's Perspectives"

Respondents from MRA and marketing indicated that efforts were being made to provide program members (engineers/managers) with access to customers. For example, one respondent from MRA cited "customer-emersion" research event conducted with members of a new program. In addition to focus groups, the research allowed each participant to spend six hours with a target customer. The respondent felt the experience was very valuable for the team members.

Another MRA respondent indicated he would be willing to assist the program teams in pursuit of customer interaction. However, the respondent's experience had been that program teams often "don't want the research to be completed." The interview results from MRA and marketing respondents can be summarized as follows:

1. Program teams may struggle to conduct meaningful MR themselves
2. It is difficult to convey customer identity and needs to program-team members
3. Program teams delay or cancel planned market research events

1. Program teams may struggle to conduct meaningful market research themselves

In general, MRA and marketing were not aware of the desire of program teams to increase the involvement of customers in the design and verification phase of the PDP. However, the respondents were aware of the minimal interaction program-tem members have with customers during the product development process. MRA was specific in stating that even if program engineers received extensive MR training, they would still struggle to avoid being influenced by their own opinions when interacting with customers. MRA was adamant that program teams should not conduct MR independent of the MRA activity. A respondent from marketing indicated, *"it isn't important for the [program] engineers to know who the target customer is."*

2. It is difficult to convey customer identity and needs to program-team members

Respondents from both MRA and marketing recognized the difficulty in conveying the identity of the targeted customer, including their needs, to the program team. Specifically, respondents from both marketing and MRA indicated that formal marketing documents intended to convey brand definition or attribute priorities were "somewhat ambiguous." This is an interesting situation when one considers that generic marketing work objectives include serving as the "voice of the customer" (VOC) throughout the product development process.

3. *Program teams delay or cancel planned market research events*

Respondents from MRA and marketing recognized the customary conflict between their organization and the program team concerning conducting MR. One MRA

respondent cited a case where a program team decided not to conduct styling research recommended by MRA. Subsequently, MRA conducted customer drive evaluations of the same product three months before production that resulted in the identification of customer likes and dislikes. Styling, both interior and exterior, was one of the items that was rated equal or below competitive products, specifically those that had not been restyled in the past two years. Unfortunately, time was not available to make significant design revisions, perform verification testing, and revise production tooling in time to support the production launch.

Needs Summary

The author utilized interview results to create a summary of needs in relation to customer involvement in the product development process. Check marks indicate that the specific respondent activity expressed the associated need. The lack of a check in a box does not mean that that activity would not support a particular need. Rather, it indicates that they did not specifically mention that particular need during interviews. An "X" in the summary reflects respondent comments that would not support a need expressed by another activity.

Figure 4.2: Needs Summary from Respondent Interview Data (not a sample of the entire population or a survey of respondent needs identification)

Needs Statement: ✔ = Supported X = Not Supported	Program Engineers	Program Mgmt.	Studio	Market Research Activity	Marketing
The program team shares ownership of market research with MRA	✔	✔			
Market research conducted by MRA only				✔	✔
Improved awareness in the PD community of the services provided by MRA	✔			✔	
Easy access to existing market research data	✔				
Improve cooperation between MRA and the program	✔	✔		✔	
Removal of sanctioning required from MRA		✔		X	
Consumer Emersion research available when program is staffed	✔	✔	✔	✔	
Customer input available at subsystem and component levels	✔	✔		✔	X
Customer input required to balance decision making	✔	✔	✔	✔	
Formalize involvement of customer during the development process	✔	✔		✔	
Avoid using customer input to finalize styling			✔		
Specify and enforce mandatory research events					✔
Customer knowledge transfer accommodates frequent personnel changes	✔	✔		✔	
Better correlation between styling research and post-introduction feedback		✔			
Ability for engineers to obtain a better understanding of the targeted customer(s)	✔	✔	✔	✔	

Needs Statement (continued): ✔ = Supported X = Not Supported	**Program Engineers**	**Program Mgmt.**	**Studio**	**Market Research Activity**	**Marketing**
Frequent customer interaction to ground engineers perspective (not necessarily to provide specific engineering solutions)		✔	✔		
Program's ability to implement a set of standardized market research tools that are simple to use	✔	✔	✔	X	
More Experiential/Qualitative Research and Less Quantitative Research	✔	✔	✔		
Better tools to support concept development and selection		✔			
Improve the speed of market research execution	✔	✔	✔	✔	
Assistance Available for PD executed market research	✔	✔			
The appropriate VOC input at the appropriate time (especially early in the PD process)	✔	✔	✔	✔	
Prioritized list of needs for targeted customer(s)	✔	✔		✔	
Access to a group of customers (internal/external) to evaluate physical properties including drive evaluations	✔	✔	✔	X	
Ability to rapidly conduct evaluations using non-engineers (using internal and external customers)	✔	✔	✔		

Chapter 5: Recommendations

Qualitative research data presented in Chapter 4 suggests that some members of OEM-A's product development community feel isolated from their target customers. The data suggests that the isolation may be more pronounced in program engineers than in the program's managers. Using these results, the strength of OEM-A as a customer-focused company can be subjectively rated for three of the seven "signs" presented in Chapter 1. Specifically, research results indicate that to some degree, OEM-A needs to improve on treating customers as partners, utilization of two-way communication with customers, and having direct interaction with customers. Subsequent qualitative research can determine the extent to which this need for improvement is representative of the entire OEM-A organization.

In spite of the research findings, sales data shows that OEM-A has had a history of developing popular automobiles in the U.S. and in many foreign markets. Is it a problem that product developers at OEM-A might be isolated from customers?

The evolution of the automobile's design (driven by customer needs as described in Chapter 2) would seem to indicate that responding to customer needs is a key competency of any automobile manufacturer. The case presented on the addition of a minivan sliding door illustrated the financial ramifications that can be incurred when a customer need is not satisfied.

In 2000, most North American factories were operating in excess of 100% capacity using over-time and additional shifts. In 2002, some industry analysts expect N.A. sales volume to be significantly lower than in 2000. Reductions in industry

volumes may increase the need to accurately predict the value of product proposals to potential customers. It is likely that OEM-A would want to address any challenges that may limit the acceptance of their products in the marketplace. The purpose of this chapter is to present recommended actions suggested by respondents to meet the challenges in using customer input to improve the success of new products. Specifically, the chapter will use the following format:

- Perceived Challenges to Effective Market Research (MR)
- Recommendations to Meet these Challenges

Perceived Challenges to Effective Market Research

Respondent data identified three key challenges in utilizing market research that must be satisfied to improve the success of new products:

1. Executive and program level decisions are made using customer input
2. Improving product developers market research skills and access to related tools
3. Collaborative market research between MRA, marketing, and the program team

Other challenges that can influence a product's success were beyond the scope of this thesis. Examples of these include engineering capability, supplier sourcing/relationships, and the limitations of market research methods.

Challenge #1: Executive and program level decisions are made using customer input

Research results, presented in Chapter 4, indicate that it is a challenge to utilize customer input to influence product decisions. Program engineers indicate a strong reliance on engineering documentation and the personal bias of the chief engineer to influence product decisions. Program managers, Marketing, and MRA all indicate the strong influence that senior executives have in making product decisions.

One respondent felt that a lack of customer data at OEM-A was encouraging the use of personal bias, especially by program managers and senior executives. One respondent, a spare tire/jack engineer, provided an example where personal bias was used to make a product decision. Limitations in storage space had reduced the allowable length of the wrench provided to loosen the fasteners holding each wheel to the chassis. Unfortunately, the shortened wrench length did not meet the minimum engineering specification. The laws of physics indicate that loosening the fasteners will become more difficult as the wrench length is shortened. The respondent felt the decision of the chief engineer to deviate from the engineering standard was based more on cost than on guarding customer satisfaction. For this respondent, customer input was limited to complaints received from other OEM-A engineers who were upset after having used the spare tire/jack system.

In addition to research data provided in Chapter 4 (interior door handle location) and Chapter 1 (drive evaluations using engineering experts), the existence of this challenge at OEM-A is further strengthened using a story cited by an interview respondent who is a program chief engineer. This respondent wanted to make executives

aware of the customer needs that were driving the product content of his program. As a result, the program chief engineer developed a five-minute video highlighting needs articulated by customers during a MR event. His plan was to show the video during the funding approval meeting with senior executives. After learning of his plan, two executives suggested that the standard Microsoft Power Point slides be used to present customer needs in place of the video. Fortunately, the program chief engineer was able to negotiate an agreement to present the video at the beginning of the meeting. As the meeting progressed, one influential senior executive referred back to the customer's unfiltered comments to check consistency versus the product proposal. The program chief engineer hoped the executives would "remember the video," i.e. that it gave them a more accurate perception of this particular customer and that it would reduce frequent executive directions that may detract from satisfying the priorities of the targeted customer.

A respondent from program engineering indicated the ramifications of this challenge are worsened when executives lease their vehicles directly from OEM-A. The respondents' perception was that executive leases are typically luxury cars and SUVs that are replaced at the beginning of each year with new models. In addition, maintenance and service is provided at OEM-A owned facilities. The respondent felt that this arrangement, which is also utilized by lower level managers (albeit with typically more affordable products), might isolate executives from typical customer experiences. These typical experiences include the purchase process, service for repairs/maintenance, and any degradation in performance/reliability after 3-4 years in service.

Challenge #2: Improving product developers market research skills and access to related tools

Based on the opinion of MRA respondents, the engineers' lack of adequate VOC skills limits autonomy from MRA to apply and access VOC tools. Similarly, program engineers indicate a lack of tools to quickly access customer input to support decision-making.

While quantitative data does not exist regarding the skill of OEM-A engineers related to MR, the author's subjective evaluation of informal market research (see Chapter 3) would indicate that improvements are necessary. For example, many of the Intranet surveys did not seek to determine if the respondent was representative of the targeted customer.

A respondent from program engineering indicated that he was concerned with conducting jury evaluations (subjective and objective) of his system using other program engineers. Specifically, he felt that the validity of evaluation results might lead to design decisions that fail to satisfy the customers who eventually purchase the vehicle.

Challenge #3: Collaborative market research between MRA, Marketing, and the Program Team

Some respondents indicated that the relationship between MRA, marketing, and the program team could be improved. In addition, the need to improve the level of collaboration between these organizations is evidenced by the following items presented previously in this thesis:

- The extensive amount of "informal" market research conducted by program team members without assistance from MRA

- To some degree, marketing and MRA are unaware of the needs of program engineers and managers for improved customer access and tools.
- Program management respondents who indicated that they…
  - did not like the "sanctioning" of MR by MRA.
  - felt that MRA did not provide "the type of customer information they needed."

Reducing Perceived Challenges to Effective Market Research

The purpose of this section is to align the actions recommended by participants to satisfy the three challenges identified for effective MR. Actions are numbered continuously to reflect the possibility that an action may support the satisfaction of more than one challenge.

Challenge #1: Executive and Program-Level Decisions are Made Using Customer Input

Improving the level of decision-making supported by customer input at OEM-A may require the following actions:

1. Increased Application of MR Tools in the Generic MR Process
2. Reducing the time required to execute MR
3. Elevating the importance of market research deliverables

Action #1: Increase Application of MR Tools

This action is intended to be an extension of the successful "Customer Understanding Initiative," (developed by MRA) where a majority of program teams were given direct exposure to their target customers in a full-day offsite. Program-team respondents indicated they would like direct contact (qualitative and quantitative) with customers during the design and verification phases of the PD process. Their primary goal was to have customer data available before beginning the development of production tooling and the completion of verification testing.

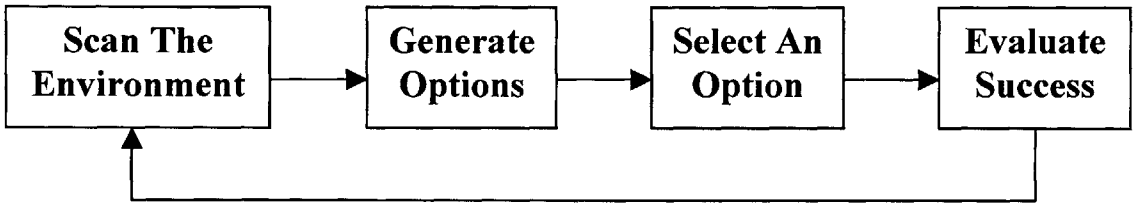
Figure 5.2 shows the needs (expressed by respondents) for customer interaction mapped to the major categories of MR tools as defined by McQuarrie [1.6]. The mapping, proposed by the author using respondent data, shows that existing market research methods may be able to satisfy the needs articulated by respondents. To the extent that the mapping is accurate, a greater focus may be required to properly apply MR methods than to develop new methods.

Figure 5.1 Mapping the Needs for Customer Interaction (those related to PD process) to Market Research Methods/Tools

Needs Statement:	Secondary Research	Customer Visits	Focus Groups	Survey Research	Choice Methods	Experiments
Better correlation between styling research and post-introduction feedback	✔	✔	✔	✔	✔	✔
Ability to obtain a better understanding of the targeted customer(s)	✔	✔	✔	✔	✔	✔
Frequent customer interaction to ground engineers perspective (not necessarily to provide specific engineering solutions)		✔	✔			
Program's ability to implement a set of standardized tools that are simple to use		✔		✔		
More Experiential/Qualitative Research and Less Quantitative Research	✔	✔	✔	✔	✔	✔
Better tools to support concept development and selection		✔	✔	✔		
Improve the speed of market research execution	✔			✔	✔	✔
Assistance Available for PD executed market research	✔		✔	✔		
The appropriate VOC input at the appropriate time (especially early in the PD process)	✔	✔	✔	✔	✔	✔
Prioritized list of needs for targeted customer(s)				✔	✔	
Access to a group of customers (internal/external) to evaluate physical/virtual properties including drive evaluations			✔	✔		
Ability to rapidly conduct evaluations using non-engineers (using internal and external customers)			✔	✔		

Program team respondents (engineers, managers) would like a simplistic framework for market research (i.e. structured common sense). Desires for a simple MR process may be the result of the complexity and time constraints of automotive engineering. McQuarrie [1.6] provides a four-step framework for decision-making, shown in Figure 5.3, which could be adapted to create a "simplistic" MR process for OEM-A. The first step, *Scanning the Environment*, (analogous to the Secondary MR - Chapter 3), provides a view of the marketplace from existing sources (internal and external to the company). *Generate Options* is intended to use qualitative MR methods to increase the product developer's solution space. *Select and Option* is intended to use quantitative MR methods to narrow the developer's focus to the option(s) that will provide the most value to the customer. The last step, *Evaluate Success,* is intended to use quantitative methods to measure the actual response of the marketplace to the option(s) selection and provide input for future environment scanning.

Figure 5.2: McQuarrie's Definition of the Decision Cycle [1.6]

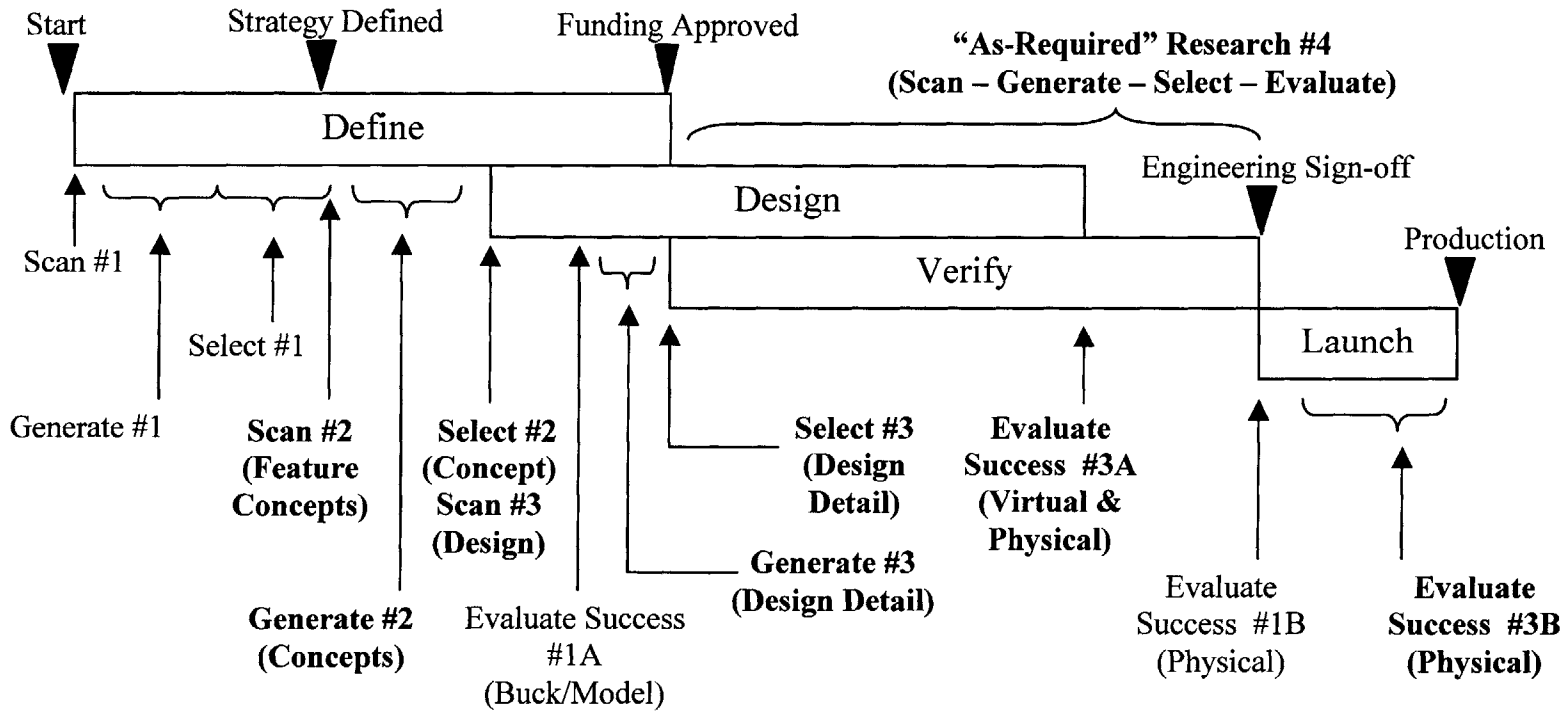


Understanding that other sequential models exist, Figure 5.4 illustrates a possible MR framework for OEM-A using McQuarrie's decision cycle applied in four sections:

- #1 – pricing, volume, feature assumptions, and vehicle attribute priorities
- #2 – feature concepts
- #3 – feature design execution
- #4 – as-required market research (i.e. MR not in the original MR plan)

Figure 5.3 Proposed Framework for OEM-A's Product Development Process

(Note: Proposed items are **bolded** and the figure is not scaled for time)



KEY

Section #1 = existing market research with focus on *pricing, volume, feature assumptions, and attribute priorities*

Section #2 = proposed market research with focus on *feature concepts*

Section #3 = proposed market research with focus on *feature design execution*

Section #4 = proposed "as-required" *market research that was not included in the original plan*

Section #1 identifies the existing MR process used at OEM-A that follows McQuarrie's framework primarily during the "define stage." MR conducted in this section is used primarily to produce feature assumptions availability, pricing, and volume assumptions.

Section #2 identifies MR used to develop and select concepts for feature execution. The proposed framework (identified by "#2") begins in the "design phase" when the program strategy is defined and the program is fully staffed by design and release engineers. *Scan* (#2) is where engineers need to obtain existing MR data to support developing design concepts. For example, MR may have generated and selected a new feature (in Section #1) that provides a powered system to automatically open and close the sliding doors on a minivan. In this case, engineers will scan (#2) existing documents (product reviews, existing research, customer demographics) prior to meeting with customers to *generate options* (#2) for feature concepts and conduct quantitative MR to *select* (#2) design concepts.

Section #3 identifies MR conducted to support the execution of design details. For example, design details for the power sliding door, identified in section #1 and conceptualized in section #2, could include items such as the open/close time, the location/number of switches, and safety features (ex. object sensing). *Selecting options* (#3) for design details may require quantitative surveys/experiments with target customers. By the end of the design phase, physical and virtual attribute prototypes could be used to *evaluate the success* (#3A) of design details prior to building vehicles for confirmation testing. The current MR process calls for *evaluating the success* (#1B)

of detailed designs in Phase 2 confirmation prototypes (i.e. the last of two prototype build phases prior to vehicles built during launch from production tools). During the launch phase, customers would evaluate the success (#2C) of pre-production vehicles before mass production.

Section #4 identifies "as-required" MR as that which is conducted outside of the MR plan. For example, design proposals to address on-going customer satisfaction issues may require the use of "as-required" market research. The design proposal to spend $25 per unit to reduce the noise of an engine component (from Chapter 4) is representative of the type of decision supported by section #4 MR.

Action #2: Reduce the time required to execute MR

Reducing the time required to execute MR should support the proposal to enhance OEM-A's MR framework and the proposed MR framework. The Virtual Customer Initiative (VCI), sponsored by the Center for Innovation in Product Development at Massachusetts Institute of Technology (M.I.T.), is one such effort to pioneer innovations in market research (using the Internet) that reduce both the financial resources and time required to conduct market research. VC methods, some of which were briefly mentioned in Chapter 3, are beginning to be trailed to provide a case for their effectiveness. The reader may want to visit the VC web site for more information: http://mitsloan.mit.edu/vc/Pages/code.html.

Program-team respondents indicated they would like to be able to consult with a standing group of targeted customers on a regular basis throughout the PD process. The volume of informal research conducted at OEM-A (Chapter 3) would seem to support

respondent data. The application of customer advisory boards (CAB), analogous to a re-occurring focus group, is one method that was suggested by respondents from program management and engineering.

Tony Carter, professor of sales and marketing at Columbia University Graduate School, conducted a study in 1996 of Fortune 500 companies regarding their use of CABs. His study found that 19 (out of 70) Fortune 500 companies used CABs and found them to be effective tools in building customer relationships. Based on Internet searches of the Dow Jones Interactive database, the following companies have developed CABs (purpose is in parenthesis):

- Apple (customers provide feedback on new technologies)
- Neiman Marcus (monitor customer merchandise preferences)
- Virtual Prototypes Inc. (software feature development)
- Northwest Airlines (better serve passengers with disabilities)
- Microsoft (establish software architecture for store-level applications)
- Gulfstream Aerospace Corp. (improve training standards)

For OEM-A, CABs could be developed to support sections #2 and #3 for concept and design development. Further research is required to determine the potential benefits of CAB compared to other MR methods

Action #3: Elevate the Importance of Market Research Deliverables

A respondent from the program's management team indicated the need to elevate the importance of market research deliverables during the product development process. Currently, the OEM-A's PDP does not call for MR deliverables to be reviewed with

senior executives at major milestones (Define Strategy, Funding Approval, Readiness to Build Production Representative Prototypes). Adding MR deliverables to major program status reviews may assist meeting the proposed challenges to effective MR.

The second action to elevate the importance of MR deliverables would be to create a category within the company database for customer requirements. Respondents from program engineering indicated they could not sort the requirement's database by those items driven by customer inputs. Currently, customer requirements such as "all power sliding doors must be capable of completing an open-close cycle within 15 seconds" cannot be sorted from thousands of other product requirements.

Challenge #2: Improving Product Developers and Market Research Skills and Access to Related Tools

Improving the MR skill level of engineers and access to MR tools may require the following actions:

4. Provide MR Training for Program Teams and Executives
5. MRA to facilitate MR execution similar to the team described in Chapter 3.

Action #4: Provide MR Training for Program Teams and Executives

Research respondents from MRA indicated that program engineers typically are not prepared to conduct market research on their own. In addition, these respondents felt the skills necessary to conduct effective market research take many years of training and practice. The definition of "effective" market research includes knowledge of the limitations of MR, the appropriate application for each MR method, and the ability to separate personal bias in preparing research materials.

In contrast to the views of MRA, program-team respondents indicated they would like to have MR tools ("direct contact with a group representing the target customers" and "quick surveys") available for their use. The significant amount of "informal" market research (Chapter 3) conducted by the program teams would support the desire of program engineers to pursue customer input using market research. Program engineers did not express a desire to operate independently of those knowledgeable in market research. Instead, they hoped MR consultants would be available to help them develop and execute market research. Based on respondent feedback, defining the degree of "autonomy" desired by program engineers in conducting MR may be the key to addressing the concerns of MRA.

The availability of MR training for program team members may be critical to increase the successful application of MR tools (i.e. Action #1). The benefits of the training may come more from MR awareness than the ability to actually plan, design and execute a MR event. MR training could include the following items:

- Purpose of market research and relationships to other PD processes
- Review of MR methods including strengths/weaknesses, proper time to apply, and the difference between qualitative/quantitative methods.
- Review of how customer needs data is translated into engineering terms

Considering the support at senior executive levels for OEM-A to become a consumer-focused company, it may be reasonable to direct MR training toward the executives and program managers who are heavily involved in making product decisions.

Action #5: Develop process for MR led by the program team

A formal process may be necessary to execute MR led by the program team in conjunction with training (Action #4) and a formal MR framework (Action #1). In Chapter 3, an example was provided where a team created an Internet survey tool and a process to manage survey execution. The intent of the process would be to accommodate the potential for MR skill deficiencies in those individuals requesting/conducing market research. Specifically, the program would rely on MRA to review a proposal for MR and make suggestions to the program team regarding items such as related MR, applicability of the requested MR method, research objectives, and generic formats (including web survey tools). In effect, MRA would serve as consultants assisting the program teams ("the research owners") in the execution of research.

A formal MR process may also reduce the amount of duplicate MR efforts. For example, one MRA respondent was aware that some of the informal Intranet surveys conducted by program engineers had already been completed by MRA. Moving "informal" market research to "formal" may allow research results to be shared with other teams as they *scan the environment* for existing MR data.

Challenge #3: Collaborative market research between MRA, Marketing, and the Program Team

The relationships between MRA, marketing, and other PD activities may be strengthened using:

6. Regular MR awareness sessions

Action #6: MRA conducts regular awareness sessions

The delivery of market research training (Action #4) should help improve the role of MRA during product development. Market research awareness sessions conducted with each program as they progress through the development process would be another way to improve relationships between the MRA and the other PD activities. As presented in Chapter 3, the majority of design engineers did not know which activity was responsible for conducting market research. Specifically, awareness sessions may be beneficial to the program team at the beginning of the "define" and "design" phases of the product development process.

Chapter 6: Conclusions and Future Research

Important Thesis Contributions

- To a degree, members of the program teams in OEM-A's North American operations are isolated from the targeted customers during the product development process
- The Internet/Intranet has provided an opportunity for product developers at OEM-A to bypass the market research activity in conducting informal market research
- OEM-A's formal market research process may need to be revised in the design and verify phases to accommodate the needs of the program teams for customer interaction.
- The isolation of product developers from their customers appears to be focused more on inter-activity (Marketing, Engineering, Market Research) relationships and less on the need for new market research methods
- In accurate perceptions exist between marketing, market research activity and program teams

Recommendations for Future Research

Recommendations for the future research resulting from the efforts of this thesis include the following items:

- Conduct quantitative surveys to determine the extent to which qualitative findings of this thesis are valid throughout the entire OEM-A organization.
- Analyze the ability of market research to provide companies with benefits such as
  - Sustainable competitive advantage
  - Developing successful products for younger customers
  - Ability to respond to disruptive technologies or changing customer tastes
- Trial MR methods at OEM-A that are led and executed by product engineers
- Trial implementation of market research using new Internet methods (i.e. VCI)
- Determine how to best balance the need to document engineering specifications while ensuring that engineers remain focused on customer-driven requirements
- Use the "Lead User Design" approach [33] and study another industry whose survival is more dependent on customer satisfaction than the automotive industry. Potential candidates could include: Retailers – Wal-Mart/K-Mart, Specialty Restaurants – Einstein Bagels/Starbucks, Computers – Dell/IBM. For example: SIEBEL advertisement in the Harvard Business Journal [35] – *"Anthony Dapolito [shown holding loaves of bread outside of his urban bakery] knows his customers by name. And he knows what they like. So they keep coming back. At Siebel, we understand why..."*

References

[1] Reinertsen, Donald G. 1997. *Managing the Design Factory*. New York: The Free Press.

[2] "GM Sales up 13% - Increase Due to Strong Retail Performance," *PR Newswire,* 2 December 2001.

[3] White, Gregory L., "GM Hopes New Styling, Price Will Boost Aztek SUV," *Down Jones Business News*, 15 November 2001.

[4] "Chrysler Group Reports November Sales," *PR Newswire,* 3 December 2001.

[5] Smith, Elliot Blair, "Early PT Cruiser took a bruisn' But resolute workers triumphed over obstacle to quick assembly," *USA Today*, 8 August 2001.

[6] Welch, David, "Born To Be a Little Too Wild," *Business Week*, 18 December 2000.

[7] Healey, James R., "Pontiac's Sporting Proposition is hard to behold. Just close your eyes and focus on Aztek's clever convenience, " *USA Today*, 2 June 2000.

[8] Healey, James R., "Chrysler Cruiser: The look and feel of success," *USA Today*, 17 March 2000.

[9] Maynard, Micheline, "PT Cruiser: Anything but pretty tame," *USA Today*, 4 January 1999.

[10] "GM Isn't Giving Up On The Pontiac Aztek Yet," *Dow Jones International News,* 26 November 2001.

[11] Vlasic, Bill and Miller, Joe, "Lutz takes GM by storm," *The Detroit News*, 19 October 2001.

[12] Ulrich, Karl T., and Eppinger, Steven D. 2000. *Product Design and Development – Second Edition*, Boston: The McGraw-Hill Companies.

[13] Jensen, Christopher, "Ford-Nissan minivan takes shape," *The Plain Dealer*, 28 May 1989.

[14] Wilson, Kevin A., "Built to order: Minivan Customers Have Been Telling Chrysler What They Want for a Decade. This Spring They're Going to Get It," AutoWeek, 23 January 1995.

[15] Connelly, Mary, "He Who Has The Most Doors, Wins?" *Automotive News*, 28 August 1995.

[16] Connely, Mary, "It's A Stretch: Will Wider Opening Help Ford in Minivan Door War?" *Automotive News*, 30 December 1996.

[17] Kerwin, Kathleen, "An Embarrassment of Minivans," *Business Week*, 11 March 1996.

[18] Gregory, Fred, "Ford is Playing Catch-up to Chrysler's Four-Door Minivans," *The Plain Dealer*, 18 February 1996.

[19] Stoffer, Harry, "Nissan Quest Adds Door, Falters in Crash Tests," *Automotive News*, 12 April 1999.

[20] Winter, Drew; "Put It In Perspective – From the beginning, the auto industry has been a tough business," *Wards AutoWorld*, November 2001.

[21] Sales Figures - Automotive News, December 24, 2001.

[22] http://www.tsl.state.tx.us/ref/abouttx/census.html (accessed 1 July 2001).

[23] http://www.autoshop-online.com/auto101/histext.html (accessed 1 July 2001).

[24] http://school.discovery.com/cgi-bin/print...2Factozscience%2Fa%2F039020.html

[25] http://inventors.miningco.com/library/inventors/blcar.ht (accessed 1 July 2001).

[26] "Brakes - History of the Automobile," http://www.geocities.com/MotorCity/Lot/3248/histo/.htm (accessed on December 5, 2001).

[27] Lamm, M. and Holls, Dave. 1997. *A Century of Automotive Style – 100 Years of American Car Design*, Stockton, CA: Lamm-Morada Publishing Company.

[28] Excerpt from *West's Encyclopedia of American Law* <http://www.wld.com/conbus/weal/wauto1.htm> (accessed 1 October 2001).

[29] Chestnut, H. 1967. *Systems Engineering Methods*, New York.

[30] Smith, Preston and Reinertsen, Donald. 1998. *Developing Products in Half the Time – New Rules, New Tools Second Edition*, New York: John Wiley & Sons

[31] McQuarrie, Edward F. 1996. *The Market Research Toolbox – A Concise Guide for Beginners*, Thousand Oaks: SAGE Publications.

[32] Grossnickle, Joshua, Raskin, Oliver. 2001 *The Handbook of Online Marketing Research – Knowing Your Customer Using The Net,"* New York: McGraw-Hill Inc.

[33] Dahan, Ely and Hauser, John R. 2000. *Managing a Dispersed Product Development Process (for the Handbook of Marketing).* M.I.T. Virtual Customer Initiative Web Page *http://mitsloan.mit.edu/vc/ (accessed 10 December 2002).*

[34] Carter, Tony. "Customer Advisory Boards," http://saleslobby.com/OnlineMagazine/0900/features_Tcarter_pr.asp (accessed on November 1, 2001).

[35] Siebel advertisement, *Harvard Business Review*, October 2001.