Enabling a Consumer Headset in Product Development

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Abstract

ENABLING A CONSUMER HEADSET IN PRODUCT DEVELOPMENT

by James Goran, Michael Shashlo, and Francis Wickenheiser

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Manufacturing-intensive companies like Ford Motor Company have come to the realization that they need to have a strong consumer focus to survive in today's competitive world. Ford has just recently announced steps to further align its program team centers more strongly with their consumers, yet the lower levels of the teams will still remain aligned around a standard part decomposition that finds its roots back to Henry Ford's vertical integration methodology. In today's information age, with the growing expectations of the consumer, as well as product complexity, it has become essential for product teams to share and communicate efficiently. It is no longer adequate for the program manager to be the sole focal point, where the voice of the consumer meets the voice of part engineering. As complex as it sounds, the consumer voice must be decomposed for delivery throughout the program team as the driving force by which the parts are engineered. Herein outlines an approach which has been called 'enabling a consumer headset in product development,' that illustrates the possibility of handle this complexity using today's tools. Bottom line: Industry is ready to take this one on. Needs analysis has established a focal point at the program team decompositional structure, product development process, and the driving management metrics and engineering specifications. Suggested are concepts that lead to a more natural and efficient way of delivering that consumer headset and these concepts are applied on three implementation projects: 1) a MIT course exercise; 2) a new Docu-Center architecture program at Xerox; and 3) a forward model 200X Mustang program. Findings are summarize into a final recommendation for future Ford program applications. The conclusion of this thesis recommends three items: 1) Introduces the Role of Architects, 2) Aligns the Organization Around the Consumer, 3) Transitions Engineering Focus to Interface Specifications.

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12 years with Ford Motor Company

- 4 years in Reliability Methods, Supervisor-RVT Quality: FRG Process Leader, RCD
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Glossary

AHP	Analytical Hierarchy Process
AVT	Advance Vehicle Technology organization
C3P	CAD/CAE/CAM/PIM
CDS	Component Design Specification function
CPARS	Corporate Procurement and Receiving System
CRDS	Corporate Reliability Data System
CSA	Chief System Architect
CTC	Concept to Customer product development process
CPSC	Corporate Product Systems Classification
D&R	Design and Release
DSM	Design Structure Matrix (N squared methodology)
EASI	Engineering and Supply Information
FIT	Functionally Important Topic
FPDS	Ford Product Development System Product Development Process
FSS	Full-Service Suppliers
GFCI	Ground Fault Circuit Interrupt
GQRS	Global Quality Reporting System
IT	Information Technology, computer data sharing
MRO	Market Research Organization
NVH	Noise, Vibration, and Harshness
OEM	Original Equipment Manufacturer, e.g. Ford, Toyota, BMW, etc.
PAT	Program Attribute Team
PCW	Product Cost and Weight
PD	Product Development

PDD	Product Design and Development MIT class
PDGS	Product Development Graphics System
PIM	Product Information Management
PMT	Program Module Team
QFD	Quality Function Deployment
RCT	Request for Cost and Timing
RVT	Research and Vehicle Technology organization
SDS	Sub-system Design Specification
Shadow Engineer	To double check the engineering of the supplier. Sometimes includes over specification
SHO	Super High Output Taurus option
SUV	Sport Utility Vehicle
VC	Vehicle Center organizations
VDS	Vehicle Design Specification
WCP	World Class Process product development process
WCR	Worldwide Customer Requirements
WERS	Worldwide Engineering Release System
WIPS	World Integrated Purchasing System
WISE	Worldwide Information System for Engineers

Part I - Thesis Conclusion and Supporting Analysis

CHAPTER 1 - THESIS INTRODUCTION

Hypothesis

This thesis addresses the question: "How to enable a consumer headset within product development" at Ford Motor Company. The term 'headset' is a metaphor to describe the complete immersion of engineers into a consumer frame of reference like headphones isolating the listener to concentrate on the music. Headset is also used in place of 'thinking,' because the way an individual thinks can rarely be changed, but the way people behave can be changed. An individual's behavior can be changed by introducing different influencing factors, and the term 'headset' is the term for a collection of structural and organizational factors that are carefully chosen to influence behaviors to listen to the spoken and unspoken voice of the consumer throughout product development. Ford Motor Company is the main company analyzed; however, the concepts and strategies herein are not limited to Ford. The goal of this thesis is to recommend process and organizational elements for product development teams of complex, high-investment products or services to achieve leadership in consumer satisfaction. The analysis is conducted by evaluating the major inhibitors and current benchmark solutions, both internal and external, and suggests a new strategy for consumer alignment. The scope of the thesis concentrates on the process and organizational structure of product development teams, but the recommendations have broad implications to the alignment of the entire enterprise. The hypothesis in short is: *Leadership in consumer satisfaction can be achieved through a natural consumer alignment in corporate processes and organizational structures of* *product development teams. This is put into practice by identifying new roles and responsibilities including: a chief system architect, a group of supporting system architects, and attribute leaders representing top-level consumer product discriminator categories. This new organizational structure is supported by traditional functional disciplines at a level below the attribute leaders.*

Corporate strategy theorists have proposed that as a company grows in size and complexity, the structures and processes established within the company must be aligned to support a unified vision, mission, and strategy. This mechanical view of a corporation is analogous to a renaissance explorer with the vision to colonize a new frontier in the west, the mission to amass an exploration vessel to navigate the sea, and the strategies to maintain course headings by astronomical navigation, conserve food rations, and avoid seasonal storms. Ford Motor Company and Xerox have carefully revised their vision, mission, and strategies to focus on the end consumer and expand the boundaries of their business. Ford is now a 'consumer company for automotive products and services', while Xerox is now a 'document company'. These changes to the basic direction of Ford and Xerox set the stage for a deeper exploration of the process and organizational enablers required to achieve a consumer headset.

Corporate Vision:

In the case of Ford, the following quote captures the change from customer focus to consumer headset:

> "The 'customer' is who we know. The 'consumer' is the ideal we want to capture"
>
> \- Ford Chief Program Engineer - Light Truck

This expands the view of 'customer' from existing owners of Ford products to all potential customers including owners of competitive vehicles and introduces automotive services as an equal profit mechanism to products. Figure 1-1 is a graphical representation of the interdependent elements that impact a company's ability to enable a consumer headset in product development. The vision establishes the foundation and is an outcome of extensive introspection by the leadership team of a company. In the case where the vision represents a change from the current direction, a gap exists from the existing state to the desired state, which the company must address by analyzing the shortfalls. Finally, by investigating benchmarks the company can establish goals and change mechanisms to achieve the vision.

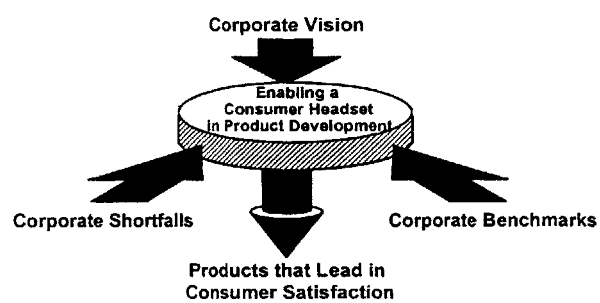

Figure 1-1 Corporate Vision

Vision

"To become the world's leading consumer company for automotive products and services."

Mission

"We are a global family with a proud heritage, passionately committed to providing personal mobility for people around the world. We anticipate consumer needs and deliver outstanding products and services that improve people's lives."

To reach the goal of becoming the world's leading consumer company for automotive products and services, Ford adopted seven strategies for leadership. These strategies were developed for the 1994 Ford 2000 reorganization but are still relevant today. They include:

- Empowered People
- Achieve Worldwide Growth
- Achieve Worldwide Product Excellence
- Be the Low-Cost Producer
- Lead in Corporate Citizenship
- Lead in Customer Satisfaction
- Be Nimble through Process Leadership

The Ford seven strategies are one way to frame the ultimate task of delivering consumer satisfaction. Companies that meet the consumer's needs better than their competition have dominated the segments where they compete. These leaders recognize that consumer satisfaction goes beyond simply providing superior components assembled into a final product. It is a deeper mindset and holistic perspective of the consumer and the product. A company must empathetically understand how their products and services are used by consumers in there lives.

With this understanding a company then must establish a decomposition of the product or service which is driven by the consumer's view of the product. The consumer's view is a collection of categories to evaluate the product balanced in a manner relevant to the consumer. These categories are termed consumer attributes and form a natural functional decomposition of the product. Furthermore, at a given level of abstraction the number and labels for the attribute categories are somewhat generic to the technological form of, and supporting infrastructure for a product. This is a result of the product, which establishes the context for the consumer.

Consumer Attributes:

Ford has established 15-vehicle attributes which are defined as a grouping of product discriminators based on functional and technological considerations to categorize the characteristic in question. This is a broad definition that combines the consumer functional features/aspects with the technology to deliver those features. By including 'product discriminator' in the definition, Ford believes a portion of the attribute set is a consumer's decomposition of a vehicle. For example, an internal combustion engine powertrain with a body enclosure mounted on wheels is believed to have a generic set of 15 attributes, which characterize the vehicle. The 15 attributes are identified in Figure 1-2. The Table separates those attributes considered to be consumer product discriminators from those considered to be internal business drivers.

Consumer Discriminator	Key Business Driver
•Safety	•Thermal / Aerodynamics
•Security	•Emissions
•Package / Ergonomics	•Weight
•Performance / Fuel Economy	•Product/Process Design Compatibility
•Vehicle Dynamics	•Cost: to the Company
•Noise / Vibration / Harshness	
•Electrical / Electronic Features	
•Interior Climate Comfort Environment	
•Customer Life Cycle	
•Styling / Appearance	
•Cost: of Ownership	

Figure 1-2 Table of Ford Attributes

Ford also believes these attributes are generic to all vehicles. From the view of the consumer, however, the attributes are generic only in the context of the features / function, technology, and supporting infrastructure of the product. A new technology, for example, will impact the attribute set. An electric vehicle will be viewed by the consumer with a slightly different set of attributes than an internal combustion vehicle. While beyond the scope of this thesis, the identification and allocation of attributes is constantly being debated within Ford. Certainly, at a high level of abstraction, all consumers will view products with a generic set of attributes. These generic product attributes include cost, ease of use, lifestyle compatibility, convenience, safety, features, and manufacturer reputation. The product provides the context for consumers to further refine the generic attributes and provide meaningful categories to discriminate between competitive products.

An ideal view of a company might be to organize the product development activities and supporting functions in such a manner as to reproduce the consumer's decomposition of the product. In the case of Ford, the consumer discriminator attributes would define the product development organization. The objective of such an organization would be simple: exceed the consumer's expectation for each category and mimic the consumer's relative balance across the categories. This is analogous to a needs-based segmentation approach where consumer segments are determined by grouping together consumers with similar attribute preferences.

Beyond categorization, an additional element is needed to completely mimic a consumer's view of a product – a holistic sense of the product that combines functional categorization with emotive responses. To a consumer, a product is synergistically greater than the sum of its attributes. The company that can translate the essence of consumer categories and holistic view of a product can capture the essence of the 'headset.' For engineered-complex products, this means the product, process, and organizational strategies of a company must support the consumer's topology and translate the holistic emotional perspective into an analytically-engineered product. For companies like Ford, with a legacy of functional departments geared to make parts, this requires the entire organization to move into the domain of the consumer to understand the attributes, and then rationalize these attributes into an engineered product while vigilantly preserving a holistic view. To achieve this migration, product development engineers and the product development organizations must be trained and measured in their ability to work between the consumer and physical part domains. Figure 1-3 graphically depicts the domains.

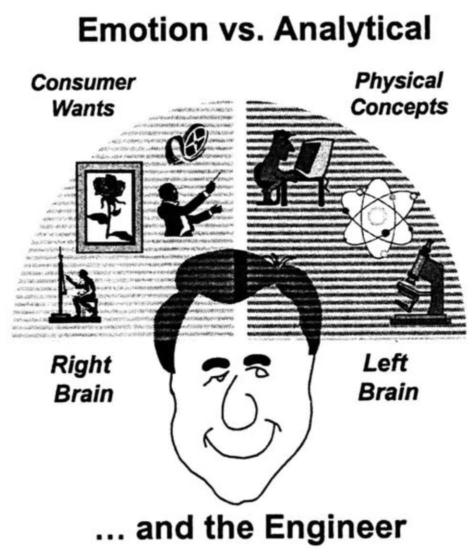

Figure 1-3 Emotion Translation

From the industrial age, as corporations viewed size as a sustaining force and developed internal expertise in ever-decreasing technical scopes, driven by efficiency to produce a larger volume of product, the engineer was removed from the practical customer domain. In reality, this is a logical reaction to consumer markets where demand far outpaces supply. But as more competitors enter a market and supply starts to match or exceed demand, companies have realized the old efficiency models do not work. In this environment, customers will purchase products that meet their needs to deliver satisfaction. The industrialized model has been replaced by a customer satisfaction model with the goal of capturing customer loyalty.

In is not the intent of this thesis to develop a method for extrapolating the essence of vehicles. Rather, this thesis assumes that a strong understanding of consumer needs, and both known and unknown wants, has been identified through a strong vehicle essence target. The challenge will be to develop a method for preserving and promoting that holistic essence within a product development program team.

(Note: "Consumer" and "customer" are used interchangeably throughout the thesis. The definition assumed for both is that they are the end buyer of the product or service, who may or may not be an existing user of the product. This specifically excludes intermediaries / brokers and focuses on the end user.)

Ford Shortfall:

With the consumer-focused vision, Ford has recognized the products and services it delivers do not completely satisfy the consumer. Ford's recent legacy demonstrates the focus on improving quality. In the 1980's Ford struggled with noncompetitive product quality that ultimately led to very poor customer satisfaction. Ford took action, instituting layoffs, downsizing, and a new approach to developing products. A new slogan, "Quality is Job #1," was introduced, which lasted into the mid-1990's. Over that time, Ford approached the quality levels of the industry leader, Toyota. But in the 1990's, as Ford and other domestic producers approached Japanese quality levels, an interesting transformation occurred in consumer preferences. As quality reached parity throughout the automotive industry, it became just one of many factors that influenced vehicle purchases. Today, influencing the purchases of vehicles, requires a total-vehicle approach using the consumer wants and needs as a target. This shift in consumer preferences drove the de-emphasis of product quality in favor of a broader measure: overall consumer satisfaction.

The philosophical shift from the "lack of failures" metric to a comprehensive metric that addresses the consumer subjective, or emotional, response to the product has not been fully accomplished within Ford. As a result, Ford continues to lag the competition in satisfying the consumer. As shown in Figure 1-4, Ford lags in consumer satisfaction initially, and the discrepancy continues to grow throughout the life of the vehicle. The poor satisfaction is particularly critical after two and five years, the time period where vehicles are replaced.

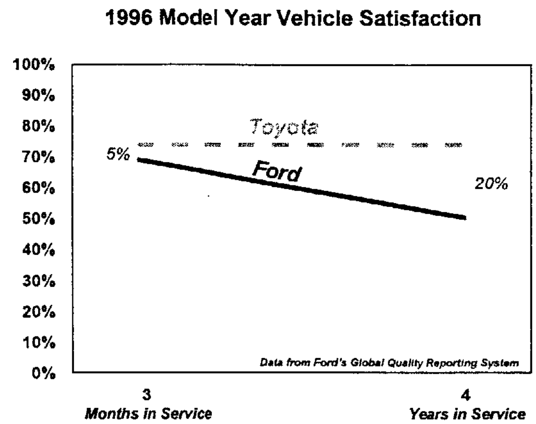

Figure 1-4 Consumer Satisfaction Trend

The emotional element:

The emotional element was even noted by John Elter, a Xerox Chief Engineer, when he said "When people buy a Ford, what do they buy? They buy the 'American Dream' as exemplified by Henry Ford... You even haven't changed his signature, using the script F."

Although understood by Mr. Elter, Ford has yet to fully address the emotional elements that contribute to increased market share. For some vehicles, like the Mustang, it is relatively easy for customers to describe the emotion, and for Product Development teams to understand the essence of a Mustang. But the recent history of Ford demonstrates that Ford has not consistently cultivated or preserved the emotional essence of its vehicles. To the contrary, many Ford nameplates have been replaced or discontinued in an effort to build a fresh consumer image and break from the legacy of the problematic nameplates. The history of nameplate revisions is described in Figure 1-5: Nameplate Turnover below.

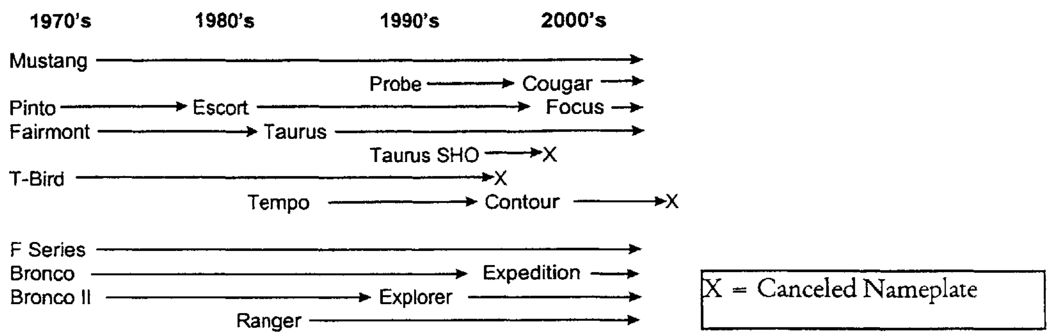

Figure 1-5 Name Plate Turnover

If we are to believe the idea that consumers approach the purchase of a vehicle from a holistic perspective, then the product development process and organization must deliver an optimized vehicle as a system that exceeds the expectations of customers and generates emotion. This vehicle level systems approach must be preserved throughout the decomposition and partitioning of subsystem elements.

Thesis Methodology

Recognizing that consumer satisfaction is composed of many factors, the focus of this thesis is the product development team structure and processes. The level of satisfaction delivered by the product or service forms the customer's predominant impression of a company. In this sense, the product represents the greatest leverage point to impact customer satisfaction.

A comprehensive study of the current Ford Motor Company product development activities was conducted, including extensive internal interviews and reviews of literature from outside sources. Academic concepts and methods, such as those taught in Organizational Processes and System Architecture, were used to identify opportunities to improve institutionalized behaviors and provide greater focus on the consumer. Internal and external benchmarking studies were conducted to validate the academic concepts and identify examples of their real-world implementation. The thesis ultimately recommends specific changes to Ford's development processes and organizational structure which will help enable a consumer headset.

Three Types of Systems:

The specific principle applied from System Architecture is the evaluation of product development activities as an intersection of 3 fundamental systems: Product, Process, and Organizational systems. All product development activities operate within these systems to create and deliver a product. The 'product' is the tangible context that in the case of most corporations is the output of their work and the item purchased by a consumer. Product is mostly the outcome, by which to target development activities and measure success in a competitive market. The inputs to actual product development are process and organization systems that combine to establish an environment for engineers to create solutions.

System Architecture also defines the role of a 'Systems Architect' as an individual with the ability to understand the emotional aspects of consumer needs and translate the art into science.

Needs Analysis:

Using Ford Motor Company as the prime case for this thesis, the typical vehicle development cycle can last as long as 36 months. If customers define success by purchasing the product, a 36-month feedback signal is an eternity to evaluate development progress. In fact, given a clearly established target segment, there remains confusion as to how to achieve, or simpler yet, how to know if the company is on the right track. In short, the target may be clear, but the measurement of success is too far out of the engineers' daily tasks. To investigate Ford's consumer satisfaction shortfall, the thesis team conducted a competitive needs analysis. The needs analysis included interviews with senior management and technical specialists from within mostly Ford Motor Company. External data was obtained from interviews with MIT faculty and students, with additional data gathered from other companies like Xerox, Toyota, and Intuit. This needs analysis identified that Ford had difficulty translating consumer wants into something that could be designed to meet consumers' holistic expectation of a vehicle as measured in consumer satisfaction surveys. The needs analysis also identified a collection of generic goals for product development teams of complex products to consider in order to develop a consumer headset. The goals were placed in a Pugh matrix that established the framework to evaluate product development teams.

Pugh Analysis:

Through various interviews of Ford and Xerox product development managers and engineers and synthesis of theoretical concepts delivered through the MIT System Design and Management program, a Pugh Success Criteria matrix was developed by the authors. Pugh analysis is the primary tool by which the final conclusions were synthesized to form the best integrated solution. Although future research and implementation trials should be conducted to refine all the final recommendations, the Pugh-generated solution was tested against the three cases detailed in Part III, and showed measured success. Pugh is a concept-generation tool that is widely used in both academia and industry to best measure alternatives for strengths and weaknesses and to build an optimal solution by combining concept element strengths.

Three Lenses:

Organizational Processes provide methods to evaluate an objective decomposition within an organization of people. In the thesis, concepts and recommendations are viewed through Strategic, Cultural and Political lenses to asses their feasibility and described below:

- The strategic-design perspective attempts to understand how the flow of tasks and information is designed, how individuals are assigned to roles / responsibilities, how these roles are related, and how the organization can be optimized to achieve its goals. [Multiple Perspectives on Organizational Process, Managing for the Future – Organizational Behavior & Processes; Ancona et. al.).

- The cultural perspective investigates the influence of values, languages, beliefs, founding legends, myths, and social norms on the organization. One of the keys to the cultural perspective is the unspoken or hidden meaning of symbols.

- The political perspective investigates the impact of goals, interests, power, and negotiations. It focuses on negotiations as the commingling of goals, alternatives, positions, and power to resolve differences in interests between parties through compromise and tradeoffs to ideally arrive at a solution where all parties benefit as a result of the agreement. Politics are a fact of business. It is necessary, and without it, the process would undoubtedly not function, as captured in the following quote:

"Politics is a good thing - the art of making things simple"

Ford Chief Program Engineer - Mustang

Issues and recommendations are analyzed and tuned through these three lenses.

Conclusion

The Chapter 2 will detail a solution for Ford to address customer satisfaction concerns and enable a consumer headset in product development. The solution was determined by the authors to encompass the highest leverage opportunities for Ford and impacts the greatest number of Pugh success criteria. Figure 1-6 below is a graphic depiction of the Pugh success criteria used to evaluate the case studies and a mapping to the three core solutions of the thesis.

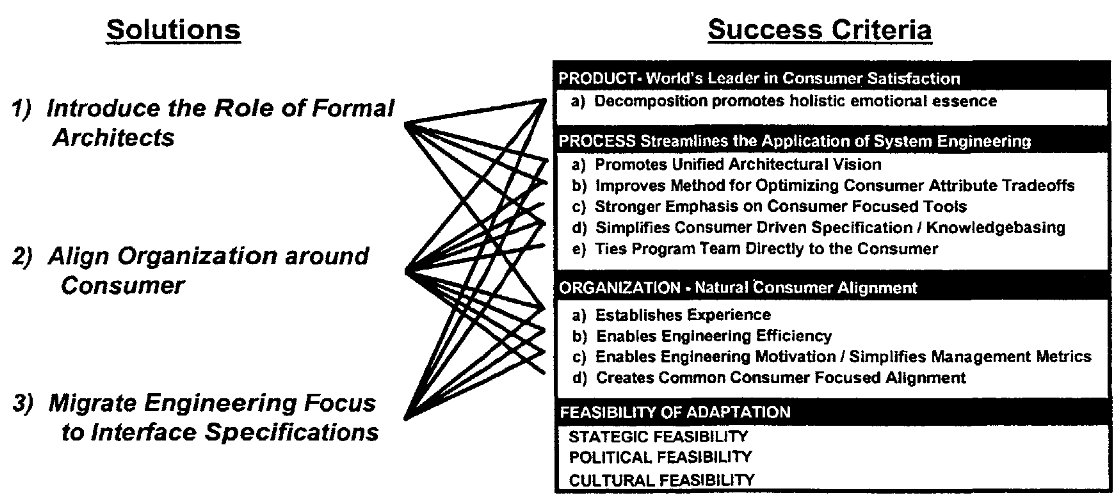

Figure 1-6 Thesis Conclusion

CHAPTER 2 - THESIS CONCLUSION AND SUPPORTING ANALYSIS

1) Introduce Role of Architects

Proposed Solution:

The system architects will be a blend of functional expertise and consumer understanding, using both to find optimal decomposition and requirement balances. Balance of requirements will be accomplished through intelligent tradeoffs, with the interests of the consumer always considered. The system architects will be ultimately responsible for satisfying the appropriate consumer attributes. Another benefit of the system architects concept is a firmly established product architecture, or set of assumptions, which minimizes the iteration and conflicts caused by incompatible requirements in the development cycle and provide clear direction and priorities for the program team.

For Ford, there will be two levels of system architects. First, is the Chief System Architect (CSA) who will be comparable to the current Chief Program Engineer in scope of authority, with some additional responsibilities to provide the appropriate flexibility. This scope includes the entire vehicle program in terms of vehicle level attributes and 1st level decomposition. Next are the system architects that report directly to the CSA. They have a narrower scope, including functional expertise in a major vehicle system, such as powertrain, and the attributes that are closely aligned with it, such as fuel economy.

The CSAs must have a solid understanding of the physical forms of the systems, although they can not be experts in every system in the entire vehicle. Similarly, the system architects must have functional expertise in the systems for which they are responsible. This is a narrower scope, but requires a deeper knowledge. Functional expertise is reasonably present in the current Chief Program Engineers and Functional Managers at the appropriate scales; however, the ability to conduct tradeoffs with consumer attributes will be a less common skill. This is primarily the result of Ford's focus on product cost, weight and delivery timing, in lieu of focusing on delivery of the consumer's requirements. What is missing is a fundamental understanding of the consumer which, over time, can be resolved by formal training and consumer interaction. The current Vehicle Engineering Manager is responsible for monitoring the vehicle program's performance to the consumer attributes, and has experienced the attribute effect of various design changes. In the short term, these managers can use their functional and consumer experiences to guide the CSA and the system architects who will also learn from experience.

The roles of the CSA and system architects are critical to the success of the program. Very early in the development process, they must work together to decompose the vehicle attributes to the major systems, and assign "form" to the "function" through vehicle architecture and assumptions. For example, the consumer want for improved handling may drive the vehicle assumption for independent rear suspension. As the program progresses, the CSA and system architects must clearly communicate the "vision" of the vehicle, and help conduct tradeoffs to optimize the total vehicle performance.

Vehicle architecture selection must be made with consideration to the "vision" of the vehicle, the performance capabilities of the available architectures, and the effect they will have on consumer expectations. Figure 2.1 illustrates the types of architecture decisions that a CSA would make, with some rationale for them.

	MAJOR SYSTEMS	ARCHITECTURE SELECTED	RATIONALE
VEHICLE "A"	Engine: Door Configuration: Suspension:	8 Cylinder 2 door w/trunk Front struts Rear solid axle w/ shocks & coil springs	"Vision" of vehicle is affordable, seat-of-the-pants performance. Reduced ride comfort and increased noise are acceptable tradeoffs.
VEHICLE "B"	Engine: Door Configuration: Suspension:	6 Cylinder, with supercharger 2 front standard doors. 2 rear doors that open toward the front Four struts	"Vision" of vehicle is upscale, technologically advanced sedan for small families.

Figure 2-1 Vehicle Architecture Decisions

More specific descriptions of the organization surrounding the system engineers and the processes that will enable them are described in sections 2 and 3 of this chapter, respectively.

Ford Motor Company's approach to setting vehicle architecture is currently very iterative, with very little discipline other than meeting time deadlines. As the deadline approaches, the program compromises the quality of the delivery in terms of completeness and accuracy. Ford has made preliminary efforts to enhance the consumer attribute presence during the early establishment of vehicle architecture or the technology selection, but still lacks the functional expertise to make appropriate tradeoffs only once, early on in the product development cycle.

In Current State discussion below, this condition is exemplified through the 1995 Lincoln Continental. This program lacked a system architect and the understanding of the consumer and as a result did not fare well in the market.

The CSA and system architects would have been able to minimize the effect of outside influences, and assure that the consumer was truly represented within the team. For example, when senior corporate management attempts to force significant changes to the vehicle late in the program, the system architects would be able to identify the entire effect of the change in terms of consumer wants, costs and timing. In this example, the misalignment of "classic" appearance and extensive technological advancements would have been identified as a disconnect for the consumer, and the cost and time impact would be quantified. Together, these risks would have been enough cause to reject the proposed changes, and improve the market success of the vehicle. The increased responsibilities of the CSA would include complete ownership of the vehicle, from the beginning to end including profit and loss.

Because many new Ford products are variants of existing products, the common belief within Ford is that there is no need for system architects. This is incorrect. System architects define how the functions are embodied in the form. Although at the macro level vehicle architecture seems predestined, the system architect is needed, and the qualifications must include a strong knowledge of the functional area, as well as an intuitive understanding of the attributes. The primary role of the architect would be to establish vehicle assumptions and targets, which requires the ability to correlate product architecture choices to attribute performance. This exercise occurs early in the development process. As the program proceeds, champions for specific attributes are needed to decompose the attribute among multiple systems, monitor progress, and help resolve conflicts. This is similar to the system architect, but utilizes a finer level of detail, over a smaller area of interest.

In the development of the DocuCentre, Xerox utilized architects with strong functional expertise and deep understanding of what would truly satisfy the consumer. Functional expertise was critical in the success of the product for two reasons. First, this provided them with the skills necessary to complete the task. Second, their expertise provided legitimacy to their decisions. Technical skills are required to make optimum tradeoffs among attributes, functions and hardware. The architect needed to understand the effects of the decisions, and address any issues caused by them. Legitimacy is critical when decisions affect systems beyond the direct control of the architect. This would often be the case when dealing with attributes, as they typically cross the boundaries of functions and systems.

Such functional expertise, however, is not developed overnight. It requires experience, motivation and skill. Toyota Motor Company firmly believes that "deep expertise in engineering specialties is essential to its product development system" (Another Look at How Toyota Integrates Product Development, Sobek/Liker/Ward - page 43). As a result, Toyota has established personnel development processes that provide engineers with deep functional expertise. Typically, an engineer will work within a specific function for 10 years before being considered for promotion. During this time, the engineer is extensively mentored by supervisors, of their direct command hierarchy. This length of tenure also promotes understanding the life-cycle of a part from concept through design and verification and into field use, and how a given sub-system interacts with the over-all vehicle. As a result, Toyota has a large pool of engineers with deep functional expertise

Architects, however, must also be experts on consumers. As the following quote implies, perfect functional expertise alone will not produce a satisfying product. The product must be functional, but must also meet the needs of the consumer.

"Customers buy the attributes, not the parts"

- Ford Director Product Development Process Leadership

Consumer expertise is arguably more difficult to achieve. To be an expert on consumers, the architect must understand their needs, even if the consumer doesn't know what they are. Simply asking consumers what they want is not enough. It requires understanding what your product is used for, the environment in which it must operate and the latent needs that offer a new product opportunity. Intuit corporation achieved this empathic level of understanding in the development of its Quicken spreadsheet software. Intuit engineers shadowed consumers while they installed the product on their computers and used it. By carefully monitoring what the consumer did and experienced, the engineers were able to identify issues with the existing product as well as opportunities for additional functionality to be incorporated into the next product generation. This insight gave Intuit a significant edge over their competition, and the product was highly successful in terms of both profitability and customer satisfaction. These achievements were possible because the Intuit engineers became experts on consumers.

Academic Concepts - Architects:

In complex products, a diversity of stakeholders and interests must be satisfied as the product moves through the development process. Within the development process a product is decomposed to simplify development and an organization is tasked to create the parts that collectively make up a holistic product. The critical responsibility to preserve the emotional part of a product and ensure the summation of pieces creates a holistic product is the province of a systems architect.

The role of the systems architect on product development teams is to "interpret the upstream influences (marketing, strategy, regulations), define the boundaries and scope of the system, define the function and decomposition of the product, define the concept, and concentrate on interfaces and abstractions." [Crawley, Lecture September 11, 1998]. The architect strives for "fit, balance, and compromise among the tensions of client needs and resources, technology, and multiple stakeholder interests." [Rechtin, Maier, The Art of Systems Architecting, Page 21]. The architect essentially spans the chasm between science and art.

> The art of architecting, therefore, compliments its science where science is weakest: in dealing with immeasurable, in reducing past experience and wisdom to practice, in conceptualization, in inspirationally putting disparate things together, in providing sanity checks, and in warning of likely but unprovable trouble ahead. [Rechtin, Maier...Page 4]

Systems architects operate at the highest level of abstraction and use a combination of insight, experience, and heuristics to simplify complex problems. Architects also understand the interplay of the product development process and the organizational structure. It is through the individual simplification techniques that the architect understands the context of product development as part of a larger system. Figure 2-2 illustrates the relationship of the architect to the expanded view of product development. The bold lines indicate the strongest relationship between the architect and steps in product development.

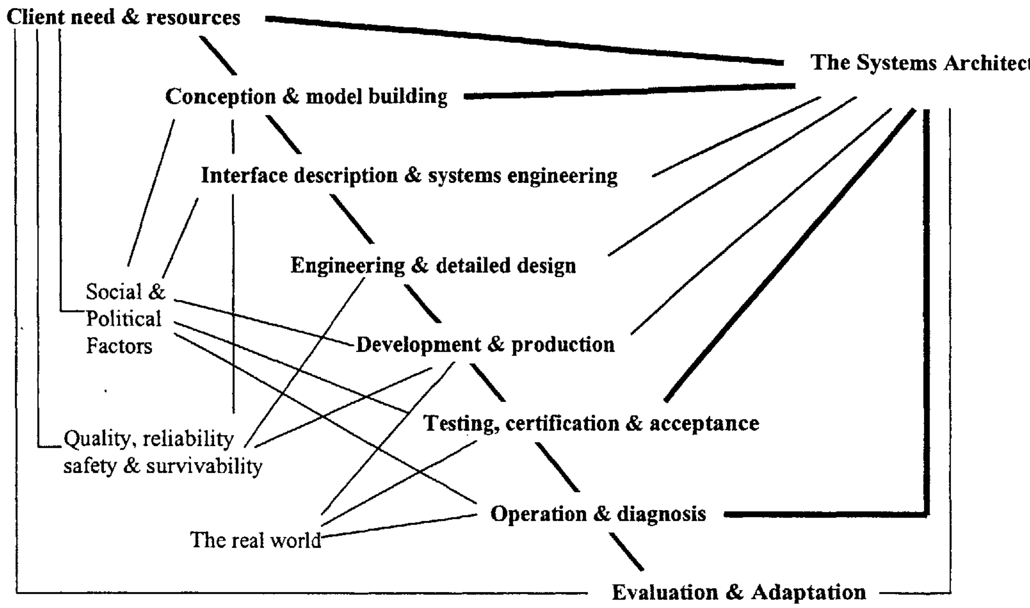

Figure 2-2 Architect and the Expanded View of Product Development

[Rechtin, Maier, Reproduction of Figure 1.3 page 19]

From this illustration we can understand the key area of leverage for a systems architect, which is the transformation of customer needs into concepts and the confirmation that the final product complies with the vision of the architect.

Current State - Ford and Architects:

Currently, Ford product development teams operate without the high-level systems architect defined earlier. In place of a systems architect, Ford creates a document called "Program Assumptions" to communicate product strategy to the product development teams. Assumptions often specify desired physical component designs and technologies to be deployed on a given program. This thesis recommends establishing the CSA role, and using that functional and consumer expertise to develop vehicle assumptions. However, assumptions are currently developed by product planners and the corporate strategy office. Some of these individuals have a cursory knowledge of the engineering, but none are experts. Lacking both up-front engineering involvement and a methodology for product architecture development leads to many program direction changes, as the engineering expertise is introduced later in the program cycle and incompatibilities are discovered.

This is very disruptive and causes confusion throughout the early and middle stages of the program (which rarely recovers, as the product verification cycle usually illustrates). This may be the single-most cause of eroded program discipline. The cost effect of this churning is illustrated in Figure 2-3.

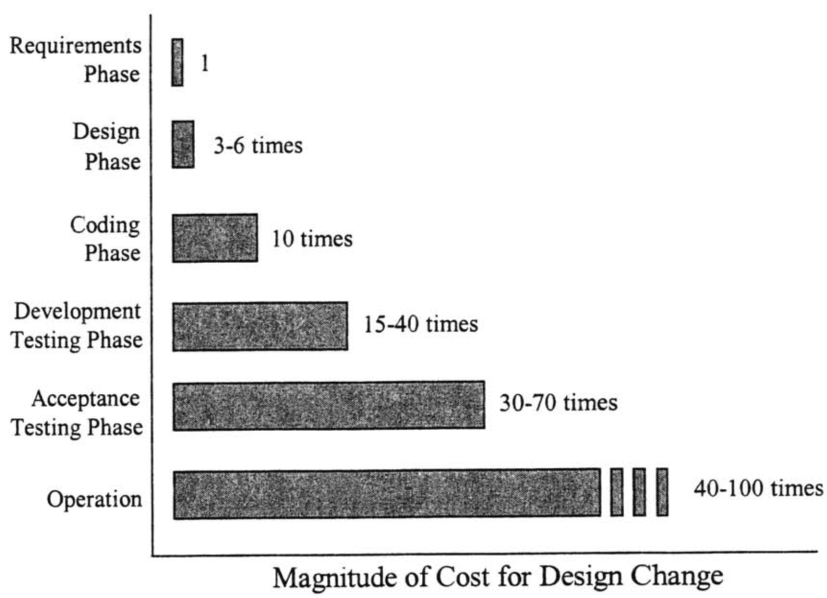

Figure 2-3 Impact of Change vs. Time

[Cooper, Wootton, Reproduction of page 18 figure]

The 1995 Lincoln Continental development program illustrates the results of late changes to product assumptions and eroded program discipline. The development of the Continental assumptions was accomplished under one program manager. Late in the program definition stages the program was turned over to a new program manager. The program was eventually delayed from a 1994 model year program to a 1995, but eventually achieved content / assumption stability. A lot of good work was brought in by the new program manager to focus on the target segment. In fact Peter Senge, author of The Fifth Discipline, worked with the team over a long weekend offsite. With a new program manager in place, the path towards success was coming into focus. But, as the team went for Appearance Approval or Styling Approval, the Chairman of the Board deemed the styling to be too aggressive. He wanted traditional body side contours, a revised body side profile, and a formal back window slope. His exact comments were, "I want to have my friends in Florida want to buy this car." Notwithstanding that a Town Car was already in production that targeted the older-market luxury buyers. Unfortunately, Ford has a history of late changes to basic program assumptions. Late changes like this are difficult or impossible to recover from. It takes the passion and belief in the product away from team members, destroys team ownership, and creates a large amount of re-work that must be contained in the remaining program delivery time. But the most serious result is a diversion from the original targeted program essence. The result of the Continental launch was mixed-to-poor, and concurrently the luxury market went soft. But within the luxury market collapse, the Continental was seen as a major technological improvement over the prior model, but the late styling change caused it to miss the targeted middle-age technology segment. Predictably, the Continental did not achieve commercial success, nor achieve high consumer satisfaction.

Transition to Proposed Solution:

Interim Attention to Architecture: The tendency for the trial-and-error approach will continue until an architecture expertise is established. There must be particular attention paid to hand-picking experts when constructing the architecture team. The key mindset is not to paste together program assumption pieces, but to carefully establish the presence of the attributes knowledge.

2) Align Organization Around Consumer

Proposed Solution:

The organization alignment shall be considered at two levels. Although beyond the intended scope of this thesis, the alignment of the entire corporation was identified as a key enabler for a consumer headset in product development. More specifically, the organization of the product development team must be revised from functional alignment to consumer alignment if consumer satisfaction is to be achieved. Although functional expertise is certainly required to develop vehicles, fixation on one's own domain will cloud the vision of consumer focused products. This is the case at Ford, from the corporate levels down to the design-and-release engineers on a vehicle program.

Ford's entire enterprise needs to be aligned along a consistent set of consumer-based objectives – consumer attributes in this case. Having every activity consumer-focused is good, but having each activity organized to support common objectives, using the same priorities and vocabulary, would improve efficiency and accuracy of product delivery, and enhance the consumers' appreciation of the product. Figure 2-4 illustrates the necessary alignment. As it shows, each consumer attribute must be addressed across all corporate activities, should provide direction and decision making rationale, and be a basis of common language. For example, the consumer research portion of the Marketing activity should be continuously in touch with the consumer, identifying needs and trends before the consumer is even aware of them. Once these are identified the Advanced Technologies activity should be defining technology strategies to address them, the Core activity should be validating the system designs and defining evaluation criteria. The program teams must apply the system designs and implement them on vehicles. The Promotional/Advertising portion of Marketing should be devising campaigns to publicize the improved attribute performance, and the Sales portion of Marketing should be echoing this message to consumers at the dealerships.

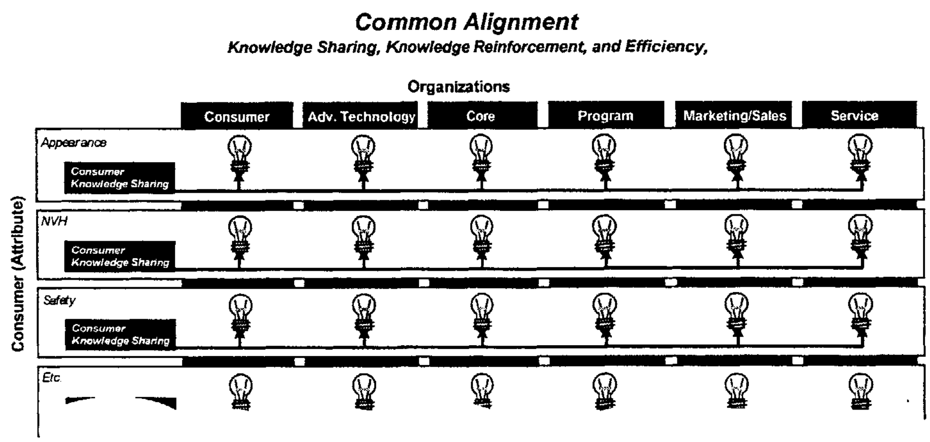

Figure 2-4 Common Alignment Around Consumer Decomposition

As a theoretical example, consumer researchers learn that vehicle handling in extreme conditions (i.e., hard turns) is a growing concern among SUV consumers. This message should be passed on to Advanced Technology engineers, who work with advanced technology suppliers to identify and evaluate emerging technologies that potentially address this performance need. Through mutual efforts, they develop a technology named Active Performance Enhancement (APE). The system is evaluated by the Core engineers, to validate its capabilities and feasibility for vehicle applications. Once validated, the program team integrates the technology into the SUV development program (which is no small task) and at the same time the promotions activity develops an advertising slogan "Go APE with your new Ford SUV," and arranges for endorsements from the Stunt Drivers Association of America stating that the SUV handles wonderfully under extreme conditions. Upon vehicle introduction, the advertising campaign begins, and Ford dealerships arrange for demonstration rides that exhibit how well this technology addresses the concern about hard turns.

A more concrete example is the Ford Windstar minivan, which has recently had great success in this area, although it occurred more by coincidence than by intent. The Windstar is targeted to buyers with families for whom the marketing activity determined that traffic safety is a high priority and a product differentiator. R&D activities had already developed models for designing vehicle structures to perform well in crashes, and developed new occupant restraint systems that enhanced this performance. The development team dedicated resources to apply these tools and use the new restraint systems. The corporate Public Affairs office funded a joint program with Sesame Street ™ to educate consumers on seat belt safety. This joint program and the vehicle's excellent performance in United States federal testing were used to develop an effective marketing program oriented around safety. Sales people conducted educational clinics to instruct customers of proper child car-seat usage. In all, these efforts have made the Windstar van very successful for Ford, and enhanced our corporate image in the process. This success was achieved through accidental alignment of objectives and priorities around consumer attributes throughout the corporation.

Returning to the intended scope of this thesis, the vehicle program team must be organized to enable a focus on the consumer, replacing the traditional functional organization. Although not achievable in the immediate future, as Ford develops consumer focused tools and skill mixes, the vision of a product development team enabled with a consumer headset can be fully implemented. The key aspects of such an ideational organization include:

- The Chief Program Engineer (CPE) is renamed and assigned the role of Chief System Architect (CSA). The CSA is responsible for initial target setting and product architecture selection. Engineering issues that can not be resolved at lower levels are resolved by the CSA. Also, he or she must frequently and consistently communicate his/her vision of the vehicle, so the entire organization understands the "soul" of the vehicle.
- Functional Managers will be renamed and assigned the role of System Architects. They are responsible for the decomposition of attributes that that have been assigned to their functional area. There will be an understanding that they will assign some objectives to other functional activities, as attributes normally cross multiple functional areas. They will report directly to the CSA.
- Functional areas will be mapped to Attributes according to their contribution to delivering the attribute. For example, the Powertrain activity will be responsible for Fuel Economy. Although many activities contribute to Fuel Economy, the efficiency of the powertrain has the single most effect.
- Functional supervisors or "chunk team leaders" will be identified as Attribute Champions - these are dedicated experts for the attribute, either immediately with their existing skills or over time as the skills develop. They report to the System Architects. These Champions decompose the attribute into requirements for the system engineers to meet. This effectively replaces the current functional

organization with an attribute organization: the design and release engineers now report to those people who are responsible for establishing attribute targets and delivering attribute performance. As Ford's Chief Engineer for Attribute Engineering said: "The glue that holds Product/Process/Organization together is accountability." Placing the responsibility of delivering attribute performance upon the engineers that design the parts represents a fundamental shift in Ford's approach.

- Design and release engineers are renamed and assigned the role of system engineers. Focusing the product system level, they establish system targets that the sub-sub-systems and/or components must meet in order to satisfy the demands of the attribute champions. These engineers resolve conflicts within their subsystem, and assure the required interface conditions between adjacent systems are achieved.
- Suppliers develop sub-systems and components that perform to the requirements provided by the system engineers.
- The current Program Management Team role is redefined as Program Leadership. This activity monitors and reports on non-attribute based requirements such as regulatory certification, weight and timing. Much of this activity can be accomplished with electronic bulletin board pro-forma's and a "management by exception" philosophy.
- Integration of Marketing, Service, Purchasing activities into team. Marketing will provide consumer research results, arrange consumer interaction with engineering activities and integrate engineering actions into promotional campaign. This has been considered at least once before at Ford. A Ford Vehicle Line Director said that "You almost want to eliminate marketing as a stand alone organization, and integrate it into Product Development. The Engineer should understand the

consumer." This reflects the dual benefit of bringing the marketing expertise into the program team, and of bringing the engineers into the consumer domain. The Service activity will be responsible for assuring that post-production concerns of the consumer are addressed, as well as coordinating the release of service parts, as they currently do. Purchasing will be responsible for arranging supplier technology presentations during the target setting phase of the program, establishing business agreements and maintaining status rating of the supplier's capabilities and performance. The ratings will be based on metrics for satisfying consumer wants.

- The organization at the design and release engineering level becomes a strong, layered organization operating under a weak, "tree" organization. The strong layered aspect will allow engineers to develop their systems with free exchange with all functional areas, focusing on achieving an optimum level of performance across attributes, without having to prioritize the attributes of his or her direct functional manager. This is feasible when the priorities of the team are well established, and verification by functional managers is no longer necessary. The weak tree aspect allows the logistics of business such as timecards, paychecks and training plans to be efficiently handled.
- Design and Release engineers will participate in peer reviews, both across the functional domains of the vehicle team and across program teams within their functional domain. Additionally, they shall receive regular input/coaching from functional experts located in Core Engineering. Continued work and access to experts within the same functional discipline, will help develop functional expertise. The continuous focus on consumers and frequent interaction with them will help develop consumer expertise. At that point, the design and release engineer will be prepared for an Attribute Champion assignment, thus retaining the knowledge within the team.

An organizational chart that reflects these recommendations, including some examples of attribute distribution, is shown in Figure 2-5.

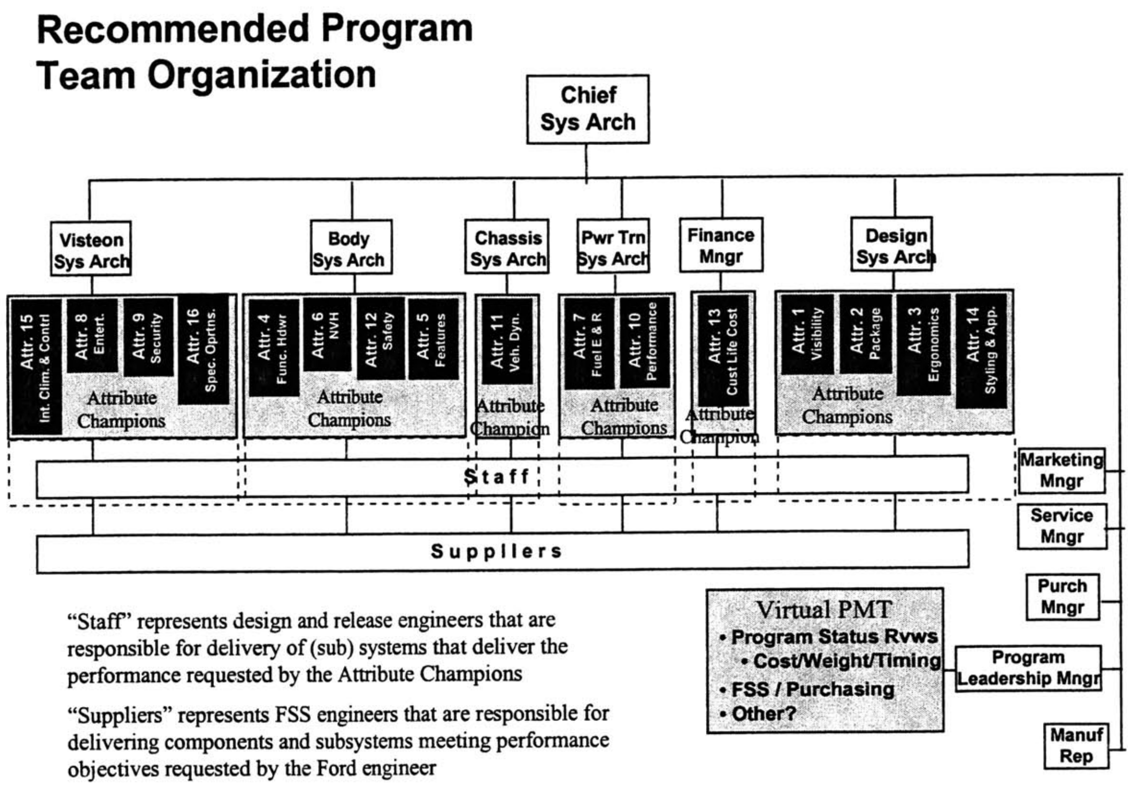

Figure 2-5 Recommended Program Team Organization

Being organized around the consumer implies more than redrawing an org-chart. It also involves providing the proper methods and tools, as well as a process that encourages their use. Although specific metrics and processes are discussed in Section 3 of this chapter, there are key aspects that must be addressed to enable a consumer headset, even with this proposed organization structure.

Helpful tools that are currently available include those developed to help Ford shift from a hardware/component optimization mindset to a systems engineering mindset.

These include Quality Function Deployment, Quality Operating System, Taguchi Methods, Experimental Design, and Robustness (to name a few). But these are not adequate to address the new consumer focus, and their incorporation into the development process, as actually practiced by the engineers, has been at a glacial pace. As described by a Ford Vehicle Line Director, "Customer data needs to be transformed into a form that engineers can use. This was QFD, and needs to be done again, in some form. To truly design products that meet consumer expectations, the engineers must be provided appropriate tools, and the process must formally require their use." Ford has abandoned the formal use and training of QFD. The process is thought to be too cumbersome to be of use in the product development cycle. Ford has replaced it with a marketing translation process that effectively cleanses the "voice of the customer" from the development process.

Examples of new tools that should be evaluated include "empathic design" and the "Language Processing" or "KJ" Methods. These methods provide a systematic approach to understanding the needs of the consumer and organizing those needs by consumer categories. Once these tools have been made available and the program teams have been properly trained, the development processes must be modified to require the use of these tools at appropriate process milestones.

Academic Concepts - Organization:

Rechtin and Maier provide an example from the satellite communications sector that helps illustrate the importance of a team led by system architects. The manufacturing activity of a satellite company insisted on a small antenna over a larger one to avoid cost overruns of re-tooling; it refused to consider the larger version proposed by communications engineers. The smaller antenna reduced operating bandwidth which reduced revenues significantly more than the cost of re-tooling.

> ...A useful management improvement would have been to set up a trusted, architect-led team to keep balancing the system as a whole within broad top management guidelines of cost, performance, risk, and schedule.
> [Rechtin, Maier, Page 62]

With the existence of systems architects within the team, the simple solution to the antenna problem would be to provide budget relief to the manufacturing department and quickly move to a holistic solution.

As discussed later in the Xerox case study, The DocuCentre program's Chief Engineer functioned as the system architect and expressed a clear vision of the product and this remained consistent over time. As a technical expert, the DocuCentre system architect allocated functionality to the appropriate elements, based on achieving the customer wants as efficiently as possible. Early in the development process, the architect was able to optimize these tradeoffs due to his expertise in both the functional domain and the consumer domain.

These early agreements in architecture drove performance, extensibility and modularity. For example, selecting a belt paper feed over a drum feed effected durability, robustness and cost. However, because the architect was aware of these tradeoffs, these types of decisions were made early in the process, and did not need to be re-negotiated later, after development work had already begun. Later in the program, as new tradeoffs were required the system architect was again able to optimize them based on his insight to the product and the consumer.

The DocuCentre model is significantly better than the typical Ford model due to the up-front involvement of the system architect in the early target setting portion of the program. This gives Xerox a significant advantage in promoting a unified vision throughout the program.

In addition to the revising the organization structure, key tools and methodologies must also be available, and their use encouraged by the development process. A concept that moves beyond the traditional QFD interview approach to obtain customer needs is the growing practice of empathic design. This technique essentially puts design engineers in the shoes of the customer by allowing the actual development engineers to view customers using an existing product in a natural environment.

> Empathic design involves viewing customers in their own setting, watching how they use your existing product and imagining how they might use products that don't yet exist. The goal: to get at important needs and desires that may not have occurred to the user.... They give the ability to bring in knowledge from the market about unarticulated needs of users and potential users, which leads to real innovations and new markets. ["Voice of the Customer Now Demands More from Design Engineers", Managing Design Engineering, June 1999]

Xerox corporation also had a strong selection of consumer-focused tools which they used in the development of the DocuCentre. Very early in the process, customer interviews were conducted to help identify the consumer needs. A critical aspect of this step is that these interviews were conducted by members of the product development team, rather than by a remote marketing activity. This unfiltered consumer input was transformed into exemplars using a process similar to the Language Processing (LP) Method, and provided deeper understanding and insight to the stated needs. Examples of the DocuCentre's exemplars include "Fewer Jams" and "Output Looks Professional."

The DocuCentre development process also monitored progress on attaining these exemplars. The performance to the requirements was tracked and reported out in regularly scheduled management reviews. In these reviews, all deviations required root-cause analysis and a recovery plan, so significant effort was made to meet the requirement and avoid deviation.

The consumer-focused development team and the use of tools to utilize the information are sources of Xerox's strength. Unfortunately, Ford does not make these same efforts, and is typically less successful in satisfying the consumer.

Boeing Corporation apparently suffers from these same issues. The results of product development without consumer focus are shown in the new Boeing 737. This example illustrates the difficulty in obtaining clear customer input and the realities of corporations. The primary customer input for the 737 was channeled through the typical marketing organization to the product development organization. In the case of the Boeing 737, the strong desire for affordability communicated by the "purchaser" of the airplane was the driver for key seat width/size compromises.

> Boeing spent 18 months consulting airlines worldwide on what the new 737 should offer. They wanted it to be faster, carry 150 passengers – as many as the wider 727 – and be capable of flying nonstop from Los Angeles to New York. And they asked for a wider cabin, or at least a more open feel, Boeing says. After all, United and Northwest Airlines, which also bought the Airbus A320, had cited its more comfortable cabin as a factor. But "executives" involved say that only Lufthansa of Germany pressed the width issue.... Affordability, however, was imperative. [Wall Street Journal, "Feeling Confined..."]

Noticeably absent from this Wall Street description is the input from end-customers and stakeholders. No doubt, a wider cabin would appeal to both passengers and flight staff to improve customer satisfaction. Also, data does not appear to exist that studied the impact of a two-inch reduction in seat width, and a three-inch reduction in seat-to-seat aisle space on passenger comfort and staff mobility.

The apparent omission of customer (passenger, flight staff) input is beginning to show up in airline quality rankings, but the impact of an uncomfortably confined trip may not be immediately discernible in quality data. As more 737s come on line, the true impact will be revealed when customers actually decline a certain airline because of the aircraft configuration. This is possible today through Web investigations of flights, aircraft, and alternatives.

Current State - Ford Organization:

As illustrated in the current organization structure shown in Figure 2-6, vehicle programs are primarily organized by functions. For example, the engineers working in these functional organizations are not directly accountable for attribute performance, as this is assigned to the Vehicle Engineering activity. This causes attribute performance to become "just another requirement," with little passion or ownership from the engineers.

In an attempt to remedy this, Ford has established the use of Vehicle Design Specifications (VDS) and Attribute Managers on the program teams. The Attribute organization adapts a generic VDS to the program, then administers and verifies the program to the VDS. Current Ford development teams have a Program Attribute Team structure that monitors program performance to attributes. However, because they lack actual design responsibility, these requirements can be sacrificed in order to achieve cost, weight and timing targets without repercussion to the design activities. This becomes more likely due to Ford's historic focus on the cost and weight metrics.

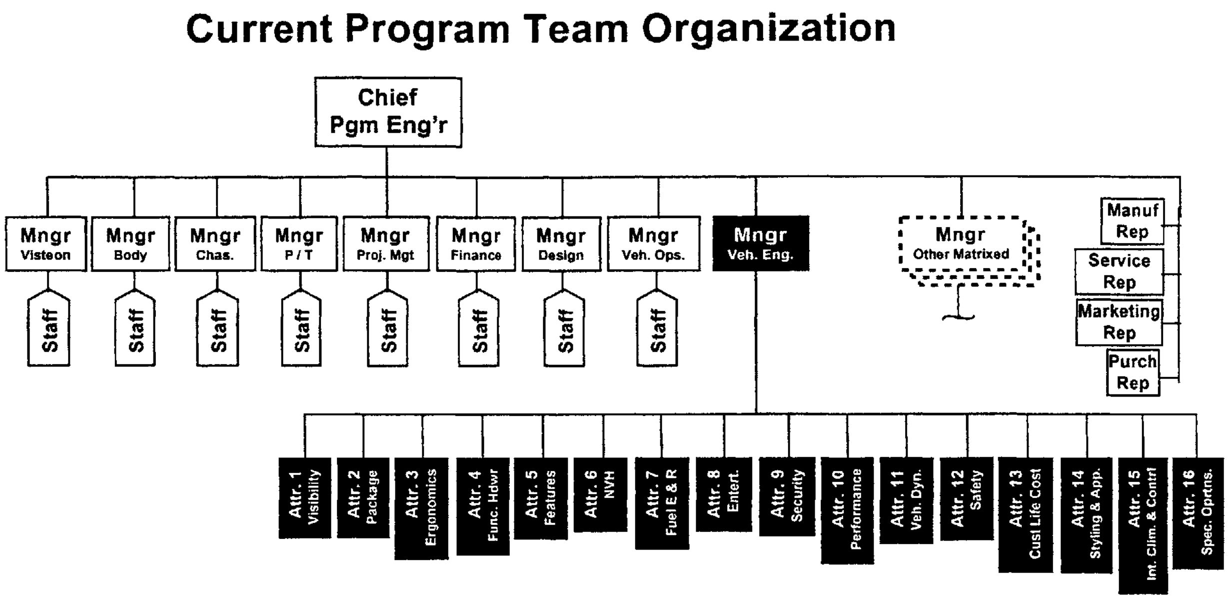

Figure 2-6 Current Program Team Organization

In addition to the organizational structure issues, Ford has few consumer focused tools and lacks the processes to encourage their use. There are currently no tools in place to enable engineering activities to directly receive the "voices of the customer," understand their meaning, categorize them, and incorporate them into the product design. Instead, as is discussed in Section 3 of this chapter, the engineers are given a multitude of requirements, which include little or no traceability to the original rationale for the requirement. These requirements should be streamlined, and supplemented with consumer-focused tools so product requirements are driven by consumer needs.

Lastly, the level of application of any tool is proportionate to it's standing within the development process. In order to drive the use of consumer focused tools, the status of their application needs to be monitored by the program. Requiring a status report-out, indicates the significance of using this tool, and helps motivate all levels of the organization. The currently available tools such as QFD and Robustness are not required by the development process and are likely to be discouraged as they consume time and resources. Because there is no report-out requirement, these tools are not seen as relevant.

These issues are exacerbated by the team's lack of direct consumer input. Because requirements are provided without context, and there are no consumer exemplars available, the design engineer is left to his or her own judgment to balance tradeoffs and resolve conflicts. A methodology to provide customer exemplars directly to the development team is needed in order to provide understanding and context.

Transition to Proposed Solution:

Because the current corporate organization is functionally organized, the Proposed Organization previously recommended would be very difficult to implement immediately. Until this corporate wide alignment is achieved, however, there are some key short term changes that would provide significant benefits. Such an interim step between the current organization and the recommended one would allow Ford to develop new skills and tools, and give the culture time to change. Aspects of this interim organization must address both the corporate alignment and the product development team alignment. Key changes include the following:

- Give the program teams control over a significant portion of the existing Technology Council budgets. This will further drive the already attribute aligned Technology Councils to justify projects in terms of consumer attribute benefits, and allow the program team to fund those that address the program team's priorities. If a connection to the attributes can not be made, perhaps the project should be re-focused towards the needs of the consumer. This shift in budget will amplify the consumer voice of the program team, while quieting the hardware biased voice of the largely hardware represented Technology Councils.

- Individuals from Marketing, Service, and Purchasing should be assigned to support each program until these activities are fully integrated into the teams. This will immediately help bring consumer expertise into the program team, although some functional focus may remain.
- Create Consumer Groups to provide strong and frequent consumer link-ups until attribute expertise / competence is built. Note this is similar to the frequent interaction of product development teams with owner groups. This is a source of competitive advantage for Harley Davidson. Ford is now applying within the Ford program team for the Mustang, F-Series pick-up's Harley Davidson edition, the 200x T-Bird, etc.
- Vehicle Engineering Manager is appointed to the newly-created Assistant CSA Position. This position is responsible for assuring attribute delivery by acting as the "voice of the customer" for CSA decisions, and providing expert direction on attribute decomposition and verification. This will be a significant assignment, particularly in the early stages of learning - their advice will be sought often. As the individuals in the CSA position become knowledgeable enough in both customer and functional domains, the Assistant CSA position will be phased out. This may be painlessly achieved by promoting the Assistant CSA, to CSA.
- Due to attributes crossing functional boundaries, engineers and suppliers may occasionally receive assignments from other managers/champions. Significant assignments will require approval from the engineers functional manager to maintain prioritization of tasks. This is a combination of strong Tree organization with weak Layered organization. Unfortunately, the local

optimization associated with functional organizations may now switch to local optimization based on which attributes are assigned to an engineer's functional manager. At least in this case, performance to an attribute is being maximized instead of cost/weight/timing.

An organizational chart that reflects these recommendations, including some examples of attribute distribution, is shown in Figure 2-7.

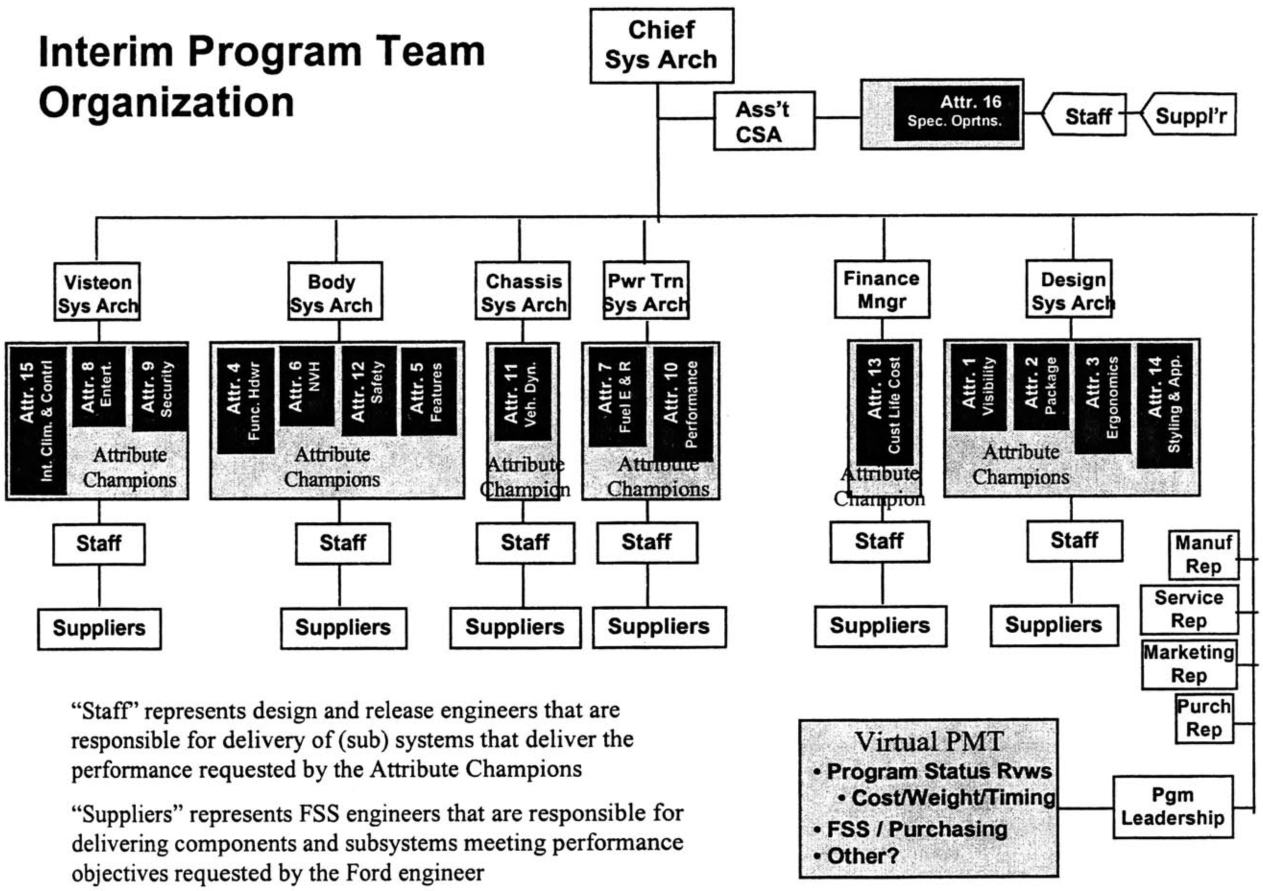

Figure 2-7 Interim Program Team Organization Structure

3) Transition Engineering Focus to Interface Specifications

Proposed Solution:

The proposed process solution has been pulled together in one illustration, Figure 2-8. It looks radically different from FPDS but really has its roots back to a less complex QFD model, bridging the levels of cascaded requirements with a select use of corporate expertise that are common in System Engineering methodology. The choice positions are System Architects and Consumer Attribute. These positions are pivotal to manage the boundary between art and science. The heart of the solution is in the use of the "Interface Specification."

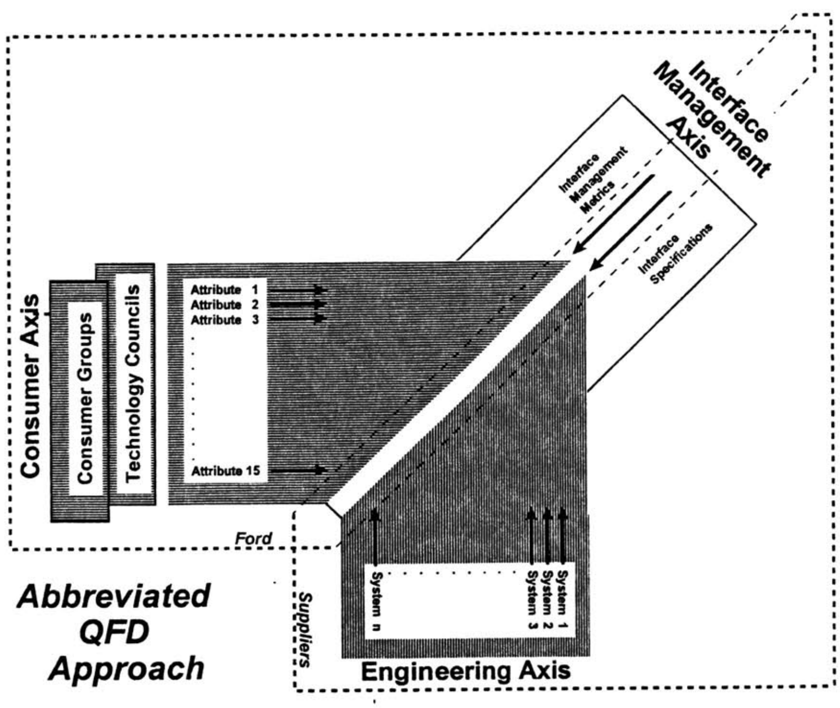

Figure 2-8 Process Representation

The interface specification is where the art meets the science. It takes a QFD approach in the way the Ford program team is aligned to the consumer, as illustrated in the attribute axis meeting the hardware axis. The strengthening of the consumer axis provides a consumer decomposition down to the interface level of the consumer wants. The system architect, is positioned along the interface axis, and provides the key translation of the consumer decomposition to actual vehicle architectural concepts. Driving along these two axes and with respective expertise will allow for more design flexibility and focus around the key specifications. The Supplier axis remains as is today, but the link to the OEM is strengthened due to the enhanced consumer-based requirements and stronger architecture. This clearer direction, which their performance is measured against, provides both flexibility and a fact-based method without a tendency to perpetuate redundant engineer activities between Ford and the supplier, known as 'shadow engineer." The key to this solution is the use of one set of specifications, the 'Interface Specifications.' These specifications are very similar to SDS's but they have traceability back through to the consumer and are requirements at the Ford / Supplier interface, established by the program team. For example, a crash event energy absorption level requirement on a seatbelt retractor, that the team expects the supplier to deliver to as a part of the full vehicle energy absorption requirement. These types of requirements are highly program dependent and so are developed as a part of a body safety interface team. The selected level for the interface specification was chosen for the many tasks it will address, in essence a focal point of the system engineering work. The roles are:

1. It is a living document created by the team where the consumer data meets the hardware decisions.
2. It is at the Ford / Supplier interface, and creates a contractual understanding of what the team will need to ensure smooth delivery.
3. It should be easily adaptable from the current SDS methodology, creating a smoother transition from SDS to interface specifications.

Academic Concepts - Specifications:

The Interface Specification methodology is founded from some of the following methodologies:

QFD: Quality Function Deployment has been effectively used to improve cross-functional communication between research and development, design, and manufacturing activities. The House of Quality is a focal point from which to focus on the Voice of the Customer as the single catalyst to drive action. It is clear that the input provided by the customers must be preserved as much as possible. For example, the stated customer need for a TV remote control that "I can see the numbers in the dark" is an unbiased statement. If this need were written as "provides a means to illuminate the number pad," danger exists by potentially biasing a need statement with restrictive boundaries which may not satisfy the stated customer need. For this reason, it is critical to allow design, marketing, or manufacturing engineers unfiltered access to customers and avoid dangerous paths created by subtle translations. The proposed interface specification process would employ this methodology and move further away from today's approach of adaptation of generic specification that have been cleansed of valuable consumer data.

> Because of the imprecise nature of the translation process, those establishing the specifications should have been directly involved in identifying the customer needs. In this way the team can rely on its understanding of the meaning of each need statement derived from firsthand interactions with customers. [Ulrich, Eppinger, Page 57]

A concept that moves beyond the traditional interview or focus group approach to obtain customer needs is the growing practice of empathic design. This technique essentially puts design engineers in the shoes of the customer by allowing the actual development engineers to view customers using an existing product in a natural environment.

> Empathic design involves viewing customers in their own setting, watching how they use your existing product and imagining how they might use products that don't yet exist. The goal: to get at important needs and desires that may not have occurred to the user.... They give the ability to bring in knowledge from the market about unarticulated needs of users and potential users, which leads to real innovations and new markets. ["Voice of the Customer Now Demands More from Design Engineers", Managing Design Engineering, June 1999]

System Engineering: In the Aerospace industry, a formal system engineering cascade of the requirements is used with extreme attention paid to each level and each interface. In theory this is the direction Ford has been going in revising its product development process. The aerospace industry requires extreme levels of reliability over a ten to twenty year development cycle. However, unlike aerospace, the auto industry requires less stringent levels of reliability and must deliver new products in a two to four year cycle. Clearly the aerospace model of system engineering must be adapted to meet the demands of the auto industry.

Toyota: In the benchmarking of Toyota's specifications, it is seen that they use a small set of part specifications and supplement these with experience and discipline to their process. This is similar to the proposed thesis solution, but the proposed interface specifications overcome the specification issues detailed in the next section.

Current State - Ford Specifications:

Ford Motor Company has developed a product development process called the Ford Product Development System (FPDS). Conventional cascade processes like FPDS tend to operate in the hardware domain and cause inadvertent cleansing of the consumer voice from the PD process.

> "Ford Jumps to Parts too early"
>
> - Chief Engineer, Ford Attribute Engineering

With the new proposal, the consumer voice will remain intact. Figure 2-9 illustrates what Ford Motor Company's current product development process state looks like, represented by the System 'V' Model. The 'V' model illustrates a simple requirement-setting process: the complete vehicle is broken down all the way to the component level; the vehicle is then designed to its particular requirements, with each requirement "verified" at various levels as the vehicle is developed. In actuality, the level cascade represented in the 'V' model is much more complex than it appears, because each of the levels in the 'V' has different domains at which a successful requirements cascade can be made. As illustrated in Nam Suh's 'zigzag' model, the cascade must be made across the Customer, Functional, and Concept domains before moving up or down to the next level. More complexity and potential confusion occurs when an attempt is made to establish distinct cascade levels, which in Ford's case include Vehicle VDS, Subsystem SDS, and Component CDS. The resulting confusion has been called 'The 'Ambiguity of Decomposition.' Ambiguity results from the lack of a consistent, clear definition of a system, subsystem, and component. For example, one engineer's subsystem may be another engineer's system. This is clearly demonstrated within Ford by the fact that some people refer to the SDS as System Design Specifications, and others refer to them as Subsystem Design Specifications.

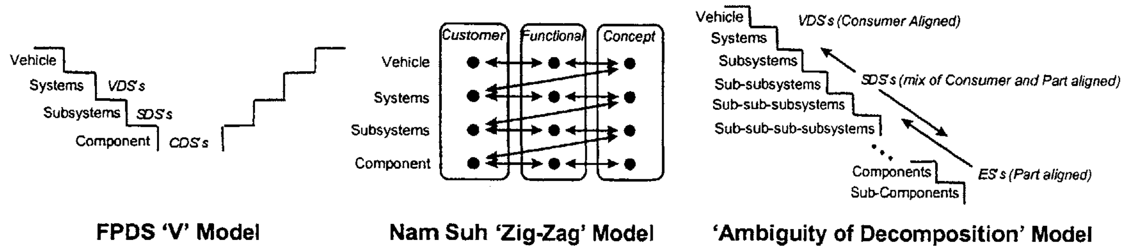

Figure 2-9 Current FPDS System Engineering

The FPDS process is accompanied by an elaborate break-down structure that attempts to define the approach. Focus is divided between VDSs for addressing the vehicle or attribute level requirements and SDSs that address System or Subsystem requirements. The introduction of two formal levels and respective specifications instantly divided engineering into two camps, captured in the following quote:

"At Ford there is acknowledged two camps, Attributes and Parts"

- Chief Engineer, Ford Attribute Engineering

An additional complexity created by the two levels was the lack of traceability and the misalignment of suppliers. Complicated because of the multiple suppliers are required to collectively deliver and SDS.

System Design Specifications (SDS) were initiated at Ford back in the early 80's. They were to introduce a Customer-Driven System Engineering methodology to the Ford requirements driven product development process. There are a few problems with how the SDSs were developed that remain to this day.

- SDSs were generated from existing Engineering Specifications (ES) that are largely part technology based. This causes design-dependent requirements that have at best, a remote tie to consumer wants

- Because SDSs were originally developed in the subsystem community instead of a vehicle top-down approach, they are heavily biased towards a subsystem optimization, at the expense of vehicle optimization. The collection of the complete universe of 90-110 SDSs does not add up to an optimized vehicle. In fact, deviating from the SDS is seen as making gains in meeting consumer wants.

"It actually feels like your are doing good for the consumer when you write a deviation from the SDS"

- Ford Chief Program Engineer - Light Truck

For example, Figure 2-10 is an extract from a seat system SDS. In the text under point 3, several engineering specifications are identified.

SEAT SYSTEM MATERIAL PERFORMANCE

Text: 1. All materials must comply with WSS-M99P9999-A1 Substance Use Restrictions. 2. Plastic materials must comply with WSK-M98P5-A Finished Parts, plastic, interior. 3. Trim Covers must comply with: 3.1. WSS-M15P2-C Performance, Seat Trim Cover Assembly. 3.2. WSS-M8P18-A1-2-3-4 Performance, Fabric-un-laminated, bi-laminated & tri-laminated. 3.3. WSB-M8P3-D1-2-3 Performance, Flexible Polymeric Film. 3.4. WSB-M1F17-B-C-D-E-F Leather - Genuine, Supple, Standard Wear, Tri-Crosslinked, High Wear, Nudo, Natural, Milled. 3.5. Must have a surface resistivity less than 10 megohms or seat assembly must be grounded to vehicle.
Requirement Number: xx-xxx
Release Date: 19-May-1998
Required Of: ARMREST, BED, BOLSTER, CONSOLE, EASYENT, FLIPFOL, FWDFOLD, HEADRES, HEATED, ICS, INSULATO, JUMP, LOADFLO, LUMBAR, MEMORY, ORNAMENT, RECLINE, REMOVE, RRFACE, SEAT, SEATCUP, SIRS, STORAGE, STSAB, STTRIM, THIGH, TRACK
Required By: CORP
Requirement Type: FUNC, MATL
Verification Method ID: DVM-xxx-ST
Requirement Owner: SEAT SYSTEMS (ID: SEAT, Release Engineer: x - AVT Seat Systems)
Targets: Design: , , Lifetime: , ,
Priority Level: SPECIFICATION

Figure 2-10 Seat SDS requirments

According to the Light Truck program team, this seat SDS requirement would have prevented the use of an actual leather seating surface and would have driven the use of an industrial vinyl in order to meet the SDS testing acceptance criteria. Unfortunately, the particular truck segment customer asked for a leather seat.

- SDSs have evolved to reflect the latest engineering knowledge, but have very little traceability back to the consumer wants that were supposed to be driving the requirements. The result is thousands of requirments with no formal way to make deviation tradeoffs.

- SDSs suffer from the "Ambiguity of Decomposition," which is a situation created by different interpretations of the definition of a system. For example, one person's subsystem is another person's system, or vica-versa.

Transition to Proposed Solution:

As mentioned previously, one of the reasons the level of the interface specification was selected was that the adaptation of the current SDSs could be done more easily. This can be done by:

- Providing SDS traceability back to the Consumer, which will allow the engineer to know the motive behind and consequences of deviating from the requirements.

- Maintaining generically only the fundamental or principle requirements that will rarely change. Today, the SDS tries to capture all consumer wants, regulations, and corporate requirements. The maintenance of such a dynamic task is nearly impossible, and generates more work for the program engineer to explain deviations from outdated specifications. SDSs should transition to only contain those requirements that will be seen as mostly static, like regulations, consumer must-haves, etc.

- The requirements of the SDS that do not meet the previous point of being fundamental or consumer static requirements, should be maintained as program implementation history only. That is go into past program history for informational use of subsequent programs.

- The SDS requirements should be migrate to the OEM / Supplier interface level and serious thought should be given to change their name to 'Interface Specifications.' This will address the ambiguity of decomposition issue, and the interface specifications will then provide a contractual agreement of the team to the program architect.

Process Flow Summary

Process Contrast Example::

The following section illustrates the revised process flow, incorporating the three proposed solutions, the introduction of the Architects, the alignment of the organization around the consumer, and the transition to the interface specification. Furthermore, it contrasts the revised process with that of the current state.

A linear summary of the proposed process steps are:

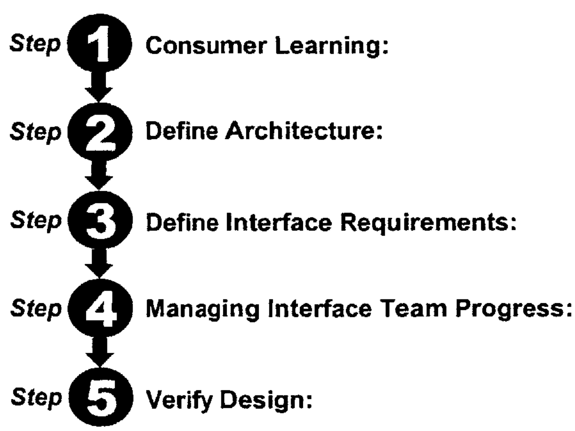

Figure 2-11 Process Flow

Step 1 - Consumer Learning: Consumer groups are established as a direct source of information for current consumer wants, and future usage tendencies. This data is used to update consumer attribute champion's and team's knowledge of the appropriate attribute targets to achieve product and service leadership. For a given vehicle, this also provides and advanced warning of changes in consumer attribute categories.

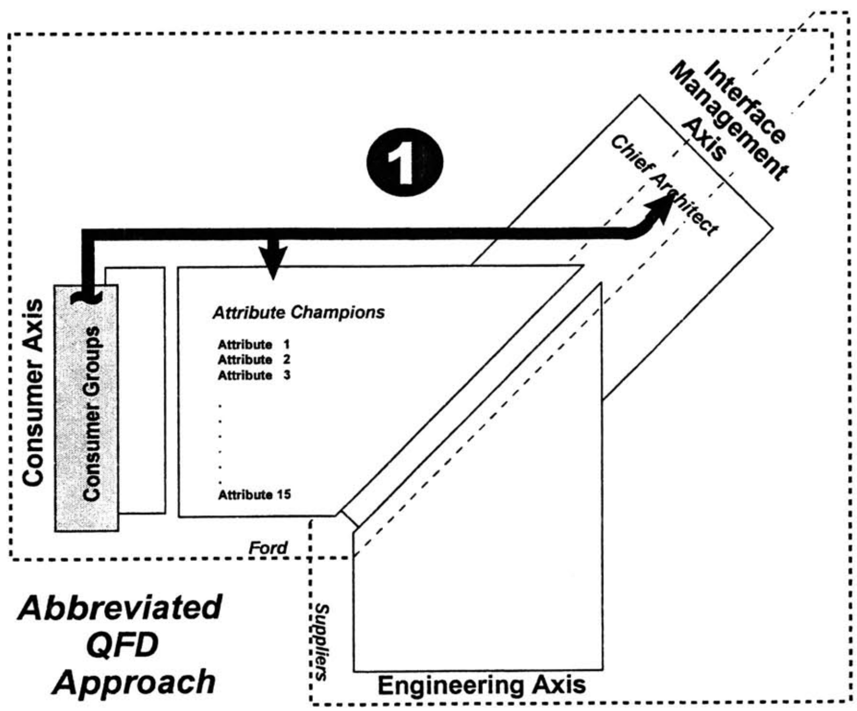

Figure 2-12 Process Step 1

For Example:

Consumer group studies, owner group interviews, and subsequent attribute balance discussion led the Mustang Chief and Attribute Champions to some of the following conclusions:

- *Ergonomics and Package - There is a need to provide better ingress and egress into the back seat*
- *Safety and Features - There is need to provide a higher technology image in the area of safety*
- *Cost and Weight - There is a need to maintain the current cost and weight levels*
- *Customization - There is a need to work with the special equipment manufacturing association to incorporate the capability for a consumer to install special equipment.*

Today this data is developed using methods employed by the marketing organization and then is unintentionally cleansed into a summary. The introduction of consumer groups that interface directly with program teams will provide the avenue for detailed consumer expressions.

Step 2 - Define Architecture: Attribute experts and system architects lock themselves in a room to develop a high level architecture that best balances the desired attribute performance. This step is highly expertise driven because it requires that detailed architectural decisions be made that will direct the ensuing development process. As diagrammed in Figure 2-13, the program team continues to draw from both the latest consumer groups and the existing Technology Councils, that are attribute aligned and are responsible for developing new technologies to meet future consumer demands.

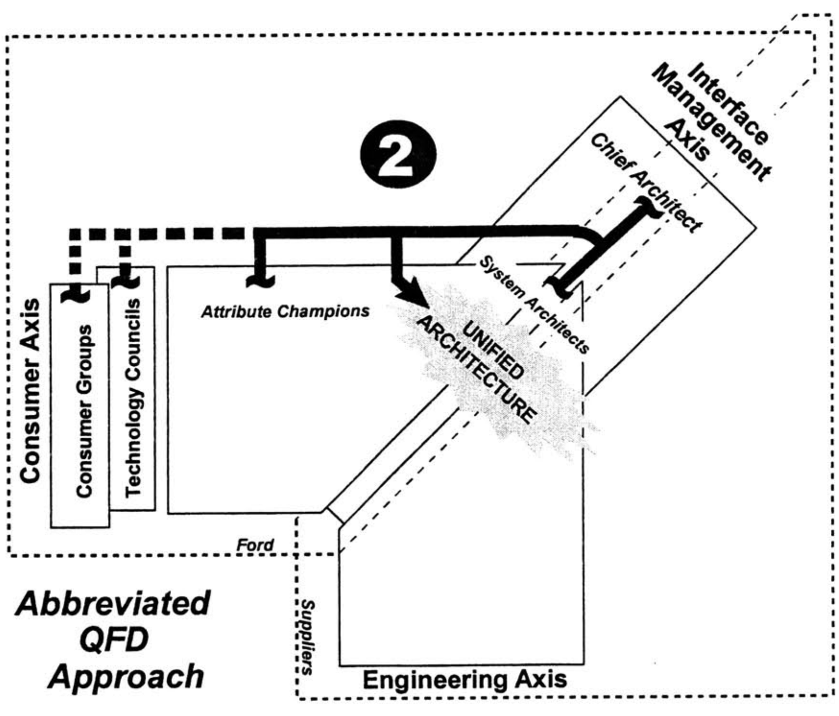

Figure 2-13 Process Step 2

For Example:

The Mustang Team of System Architects and Attribute Champions decide the following changes to the architecture to achieve their desired attribute performance:

- *Add the Seat Integrated Restraint System that the Technology Councils assess as implementation ready. This will address the Ergonomics, Package, Safety, and Features attribute. However, it will adversely affect the Cost and Weight attributes*
- *Implement Cost and Weight reductions on the following:*
    1. *Deleted floorplan reinforcements where old restraints mounted*
    2. *Identified assembly savings now that restraints assembled to seat, prior to final assembly plant.*
    3. *Use smaller retractor because less seatbelt webbing is required, due to the fact that the retractor now moves with the seat.*
    4. *Implement new plastic roof panel, replacing sheet metal. This is not only cheaper and lighter, but allows for assembly efficiencies in the loading of interior systems prior to installing the roof.*

All the architectural experts are in the room with the consumer attribute experts, to make these key trade-offs and optimize the attribute balance in he interest of the consumer. This is different from today, where the vehicle architecture is assumed, due to the large carry-over content and similar architecture vehicle-to-vehicle. Today, the vehicle architecture is pre-destined by assumptions that are developed by product planners that rarely have the architectural or engineering expertise to make feasible tradeoff decisions. These planners also work with second-hand marketing consumer data, which makes it more difficult for the tradeoff decisions to stay true to the original consumer intent.

<u>Step 3 - Define Interface Requirements:</u> System Architects run respective 'Interface Teams' with affected attribute champions and suppliers. The goal is to tailor the interface specifications and define lower level hardware to best meet attribute and vehicle architecture intent.

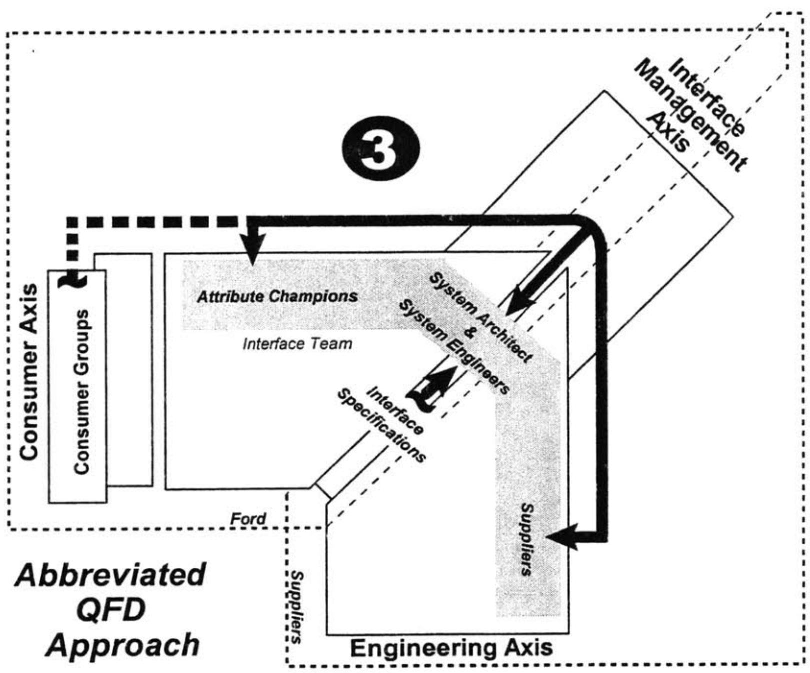

Figure 2-14 Process Step 3

For Example:

The team is led by the System Architect that participated in defining the vehicle architecture and Attribute Champions that also participated in defining the vehicle architecture. The team starts with the architecture assumptions, previous vehicle interface specifications, and begins to tailor the specifications to their vehicle, while defining preliminary hardware. Note that this is change from the belief in a 'contain-all' generic *specification like the SDS. Generic documents have rarely been kept up to date to the satisfaction of a truly consumer driven team. What is being proposed with the interface specification is that only the fundamental or principle specifications (e.g. corporate and regulatory) are maintained generically. These requirements are supplemented with the program team's latest consumer knowledge combined with interface specification knowledge from past programs. This will establish program specific interface specifications that have both a strong consumer basis and a strong sense of ownership by the program team.*

Returning to the seat integrated restraint example, the team tailors package, ergonomic, safety, and feature, cost, and weight attribute driven specification targets. The current vehicle cost is used to establish cost and weight targets.

- *Rear seat ingress/egress width enlargement target*
- *Seatbelt shorter retraction time target*
- *Cost/Weight Target*
- *Maintain previous vehicle(s) seatbelt pull strength target*

The key to this process is to harness the team's expertise and knowledge to manage its own vehicle subset. The same expertise and knowledge will help the team identify when it requires assistance outside of its team boundaries. The tracking and reporting duties would better utilize Information Technology (IT) solutions which is a radically different use of teamwork than is seen at Ford today. Today the team assembles for the tracking and reporting, and knowledgebases, such as today's Program Module Teams (PMT), cost, weight, timing tracking and reporting meeting forums. The use of IT solutions have been created to help the engineers do their 'engineering' without having to leave their desks. Good engineering can only occur when engineers of interfacing systems and champions of consumer attributes interface through teamwork.

Step 4 - Managing Interface Team Progress: The specific design is managed at the Consumer and Engineering Axis interface, using the interface specifications and interface management metrics as the focal point for team performance. This will enhance ownership of the design metrics because they were tailored and defined by the same team. Meanwhile any tradeoffs between teams or deviations to vehicle architecture direction within a team are discussed at chief system architect major issues meetings, where all the system architects and attribute experts are present. Figure 2-15 illustrates the guidance that the Interface Specification, Interface Management Metrics, and the Chief System Architect provide to the team.

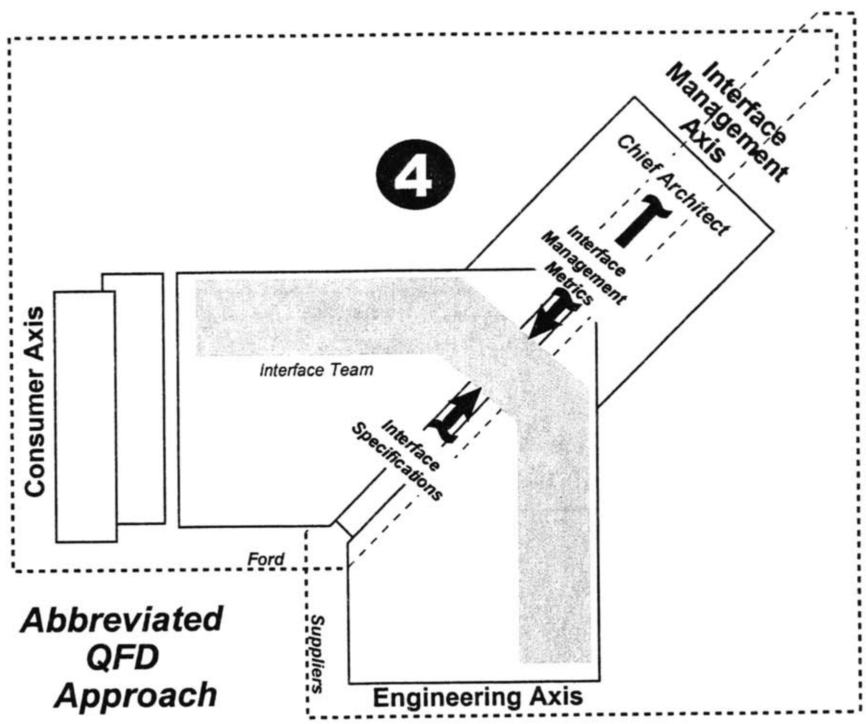

Figure 2-15 Process Step 4

For example, Tradeoffs outside of the Restraint Safety team if the Seat Integrated Restraint requires a little more liberty with styling features from the appearance attribute champion in order to accommodate the required structural integrity. Additionally, if the Seat Integrated Restraint requires further modification to the floorplan from the structure subsystem engineer to accommodate an improved mounting proposal (Improved, meaning it provides improved performance in consumer attribute areas, for example cheaper, improved ingress/egress, reliability of performance, etc.). Feasibility issues will be kept at a minimum through introduction of true architectural; and consumer experts in setting the architecture in the Step 2.

Again, the tracking items uses IT solutions, and the interface specification development is dominated the architectural and consumer goal performance. This approach is much more focused than today's multiple specifications, Program Module Team (PMT) status reporting meetings which are led by managers that were not involved in the assumption setting process and do not recognize Product Attribute Team (PAT) activities.

Step 5 - Verify Design:

First, verify the design meets the team's interface specifications.

Second, verify design meets expectations of the consumer groups.

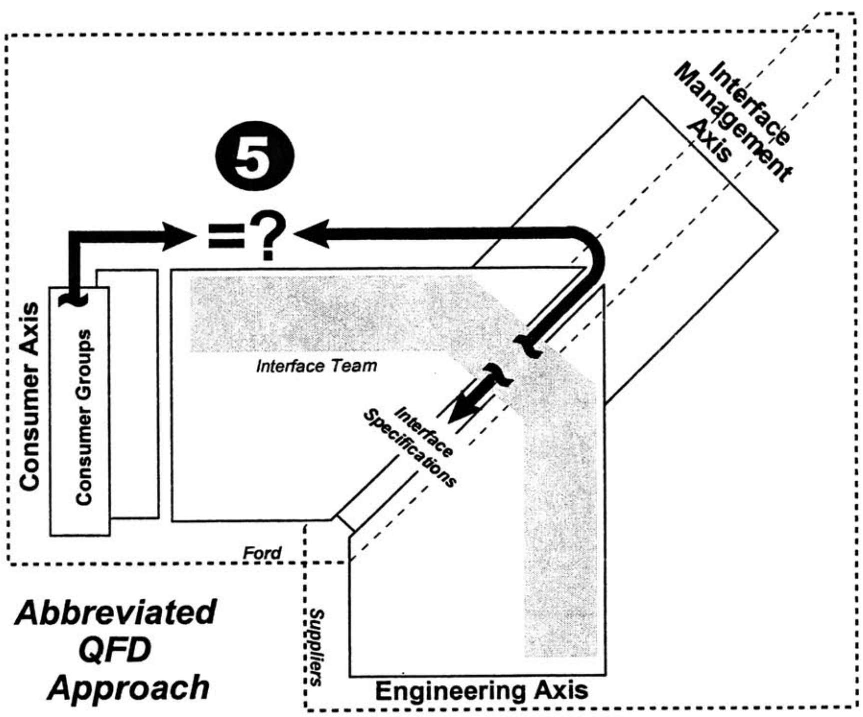

Figure 2-16 Process Step 5

For Example:

All designs should be verified to the program specific interface specifications first, then ultimately verified with the consumer group. This is similar to SDS steps today but with a much more consumer focus goal and with a stronger team ownership of the specification. In contrast to today, design performance verification will occur with all attention focused on one set of specifications versus several levels owned by different organizations. There *will not be the confusion of today's system of whether it is the ES, SDS, VDS, or some other knowledgebased, generic requirement that was suppose to be met. The team owns the Interface Specification that it signed up to delivering. Furthermore, the team now has access to the consumer group to get true sense of consumer acceptability or excitement.*

Cultural and Political Comments

Cultural Analysis:

Expertise in the system and chief architect positions, along with attribute champions that understand hardware, will be difficult to find at first. However, with emphasis from senior management on attribute skills and of a new career path, this will promote a natural desire for individuals to strive for consumer expertise. Furthermore, commensurate with consumer expertise will come a more relevant challenge to generic knowledgebases. This will drive a more evolutionary approach to how specifications are maintained and improved.

Political Analysis:

Politically, the shift from a strong functional or hardware based management to an attribute based management will meet some resistance. However, strong factors like the current direction of Ford, and the message that senior management would send by raising the hierarchical level of importance of the lead Vehicle Engineering person (manager of current attribute experts, matrixed to the program team), will only make the migration to the strong attribute approach the politically correct method to support.

Part II - Supporting Research

CHAPTER 3 - FUTURE RESEARCH

The primary recommendations of this thesis provides only a start for what can and should be addressed to ensure continued leadership in consumer satisfaction. The conclusion addressed the program team structure and how to better align around a consumer preference promoting decomposition. It also looked at how to simplify the specification and measurable process by recommending a prime focus be established at the process complexity point. Specification is to be used only as a supplement to the expertise areas of System Architects and Attribute System Engineers. Third and the last major point addressed is the introduction of natural motivators.

Future Research

Areas of future research are many. This thesis provides some fresh new approaches to looking at processes and organizational structures, and provides some starters in how to implement. Like many new ideas when first discussed, many more questions arise than can initially be tackled. Prime areas of future research are as follows:

Implementation of Thesis Solution:

The next step for future research would be to apply the main thesis elements on an upcoming program. The current attribute decomposition methodologies and results are a source of debate within Ford, so a more comprehensive methodology needs to be developed through implementation evolution. The thesis Authors will be addressing this in future work assignments.

Knowledgebasing or Knowledge Management:

How to develop and implement knowledgebased information to complement the natural consumer alignment of a product development process and program team. How to simplify and ensure a natural update of the data.

The Power of a Common Consumer Alignment throughout a Corporation:

This thesis only touches on the surface of this unbridled source of power. This thesis explores the optimal organization of a program team and skims the surface of some benefits of aligning other corporate organizations around the same alignment. An area of deeper study would be to look at all the major impact organizations within a company as Ford and optimize around the consumer to best work for the optimized corporate whole. This would be an excellent opportunity to use the Design Structure Matrix tool.

Career Paths:

This thesis outlines a general approach where greater motivation should be established around consumer thinking. It provides some examples in what would be expected as motivation factors cascaded down naturally through management. More study should be conducted on this consumer aligned concept. Some software industries may already be using this type of model. What are the key motivators and career path enablers have been overlooked during this period of trying to drive manufacturing companies like Ford's stock to behave more dynamically as software companies. This would provide an excellent opportunity to explore the rooted differences in consumer behavior between manufacturing and software companies.

IT Enabled PMTs:

The best use of the program subteams like PMTs and PATs are the fact that engineers get to interface. This thesis proposes removing the team redundancy and making the PAT or attribute team the prime interface, and taking the remaining PMT or hardware team tracking tasks and using IT solutions to enable. Further research should be done on how to implement IT solutions to optimize team efficiencies. For example, the cost, weight, timing, risk/opportunity tacking and reporting.

DSM Mapping Functional Areas to Attributes:

Deeper Exploration of SDS through DSM:

CHAPTER 4 - TERM PROJECT TRIAL

Chapter 4 outlines the first implementation trial of the thesis ideas previously delineated. It is a very small and abbreviated approach, but does illustrate contrasts in behaviors that expected. Behaviors tended to revert to component or hardware thinking but were always brought back to the consumer domain with the enhanced consumer alignment concepts.

Chapter Introduction

The thesis authors and four other classmates were involved in a project that was the main deliverable of the MIT Product Design and Development course. The project objective was to develop a product that addresses a consumer need or niche, using the latest product development practices. This team developed a power-off timer device to be used in place of a standard outlet, employing a timer chip to de-power the outlet after preset duration activation.

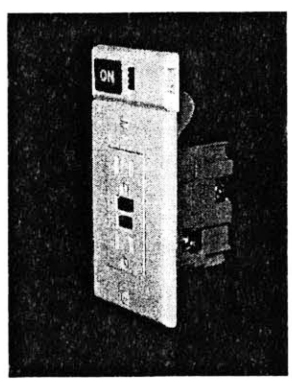

Figure 4-1 Power-Off Timer Product

The following illustration, Figure 4-2, shows the end product that was developed to fill the consumer need to have outlets that will be safeguarded against leaving on small appliances, power tools, etc., therefore mitigating the chances of house fires, or even helping to cut down on energy usage costs. The team mutually agreed that this project would be an excellent chance to test some of the thesis elements reviewed in the previous chapters.

Product Elements

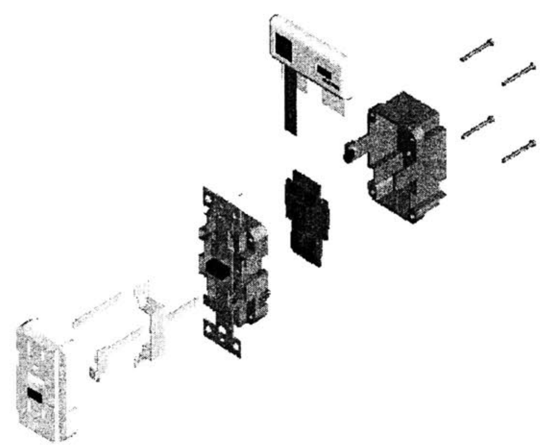

Figure 4-2 Product Assembly

The illustration above is an exploded view of the solid model CAD file. The product was developed within timing and cost guidelines, with minimal deviation from the originally set consumer preference targets. A lot of this was attributed to the application of this thesis solution recommendations. The use of a strong consumer alignment in the team decomposition, and consumer measure of the team's success. A lot of the thesis ideas were refined during the PDD application.

Product a) Decomposition promotes holistic emotional essence:

The architecture of the product was chosen specifically to simplify the 'module' interfaces. The modules were divided into: First - the GFCI outlet core itself, which was left to be left as production as possible, to best maintain product reliability and to limit cost expenditure. Also to keep the learning curve of the consumer at a minimum. Second - the user interface control module, which was an assembly of activation switches and dials that was tethered by a wire ribbon so it could easily be outsourced; Third - the timer circuit board, that provides the brain. Experts were assigned to each based on interest and knowledge. Figure 4-3 overlays team members as assigned to their respective subteams over the architectural decomposed flowchart.

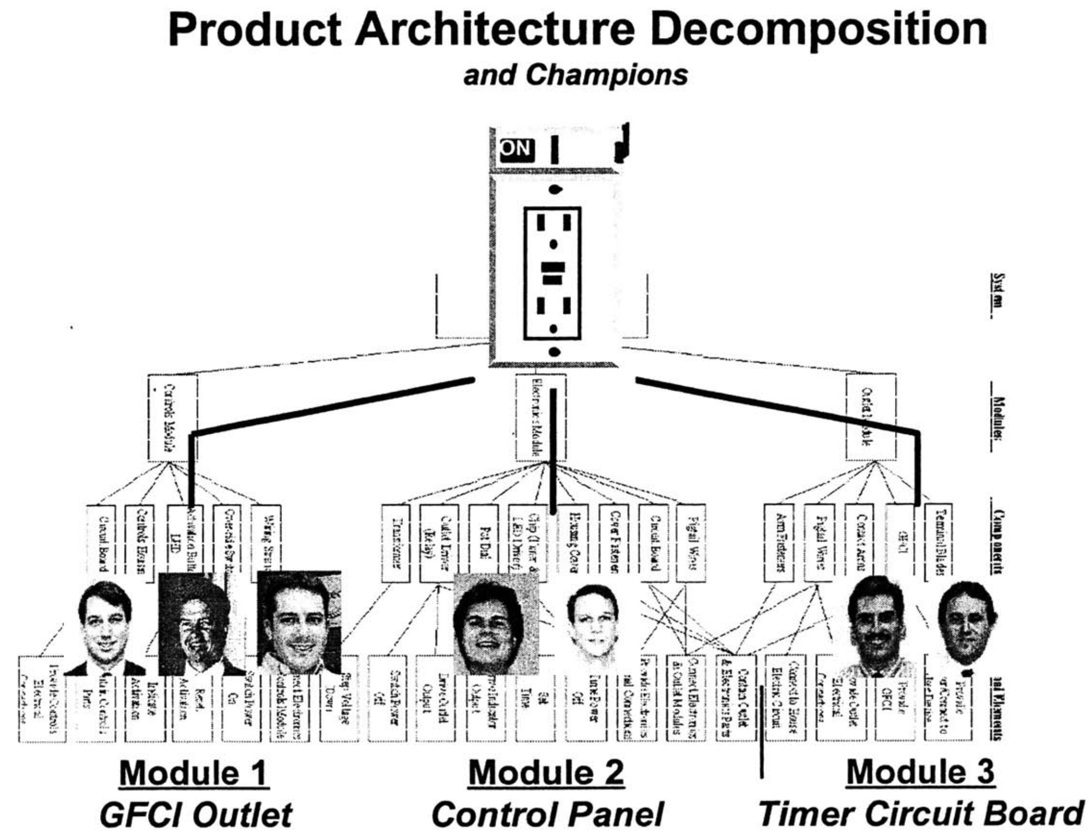

Figure 4-3 Product Decomposition

The architecture was also chosen for the reason that it provided modules that can champion specific consumer attributes almost exclusively, with very little division between modules. The attributes were developed using a QFD methodology of grouping common consumer wants. These were also contrasted against the Ford Motor Company 15 attributes. There was some similarity between Power-Off Timer attributes and Ford attributes.

Power-Off Timer	Ford
1) Easy to Use	Ergonomics
2) Value	Customer Life Cost
3) Safety	Safety
4) Appearance	Styling and Appearance
5) Regulations	---
6) Easy to Install	Ergonomics (repeat)
*	Features
*	Security
	Interior Climate Control
	Entertainment
	Functional Hardware
	NVH
	Vehicle Dynamics
	Fuel Economy and Range
	Performance
	Special Options
	Visibility
	Package

* A couple of seventh and eighth attributes the team did address informally were number and technology attractiveness of features. The safety attribute did include security for the Power-Off product where there is a more natural separation of the two attributes in Automotive. The same is true for Package as a part of the Easy to Install Attribute. Figure 4-4 outlines the assignment of the attributes to the module that has the most affect.

Module 1 - GFCI Oultet	Consumer Atrribute 3 - Safety Consumer Attribute 6 - Easy to Install
Module 2 - Control Panel	Consumer Attribute 1 - Easy to Use Consumer Attribute 4 - Appearance
Module 3 - Timer Circuit Board	Consumer Attribute 2 - Value Consumer Attribute 5 - Regulations

Figure 4-4 Attribute to Module Decomposition

As the table above illustrates, two attributes were championed by each team. Overall Reliability and Function were not treated as separate attributes as Ford Motor Company breaks out. Reliability and Function are to be achieved in all the attribute areas per the team targets as consensed during performance tradeoff discussions during the integration meetings, process discussed later.

Process Elements

Process a) Promotes Unified Architecture:

The architecture was kept as flexible as possible to keep from overlooking strong elements of alternate proposals, which would be more difficult with a more complex project. There was much debate and discussion around the architecture. All team members realized that it was critical to have a good, meaning easily feasible, architecture that delivers the consumer wants to an optimized level. The amount of time put into the discussion over architecture delayed the freezing until late than originally desired. However, the flexibility left in place by the late freeze and the firm belief in the importance architecture ultimately led to the success of the product.

For example, two architecture were originally discussed:

1) <u>Mid-term level / Mechanical Actuation:</u> This proposal was very easy to install and it used the existing switch plates on the market. This better performance in the Value attribute, because no new plate is required. Also better performance in

the Easy to Install attribute for the same reasons. However, it did have some appearance concerns over its raised above the switch plate appearance.

2) Module / Remote add-on: This proposal was to have a separate timer box with a tethered remote pad for actuation. So a consumer would use his or her existing outlet, but wire in the box and replace the switch plate with the remote pad outside the plate. This improved the performance greatly to the Appearance attribute, but had some serious functionality concerns, mainly it would de-power not only the outlet wired into, but all of the outlet protected by the GFCI circuit.

Using a pure Pugh mind of thinking the team combined the two architectures to generate the ultimate architecture in consumer performance and more modular than the mechanical architecture proposed at the midterm review.

Process b) Improves Method for Optimizing Consumer Attribute Tradeoffs:

Similar to what this thesis is ultimately recommending, the team had a strategy of weekly integration meetings. This was where the Chief Program Engineer equivalent, the 'Integrator' was responsible for (equally as the rest of the team in this case) facilitation through progress discussion, making sure the consumer attributes along with the modules were kept optimized. This was nicknames 'QFD Process Thinking'.

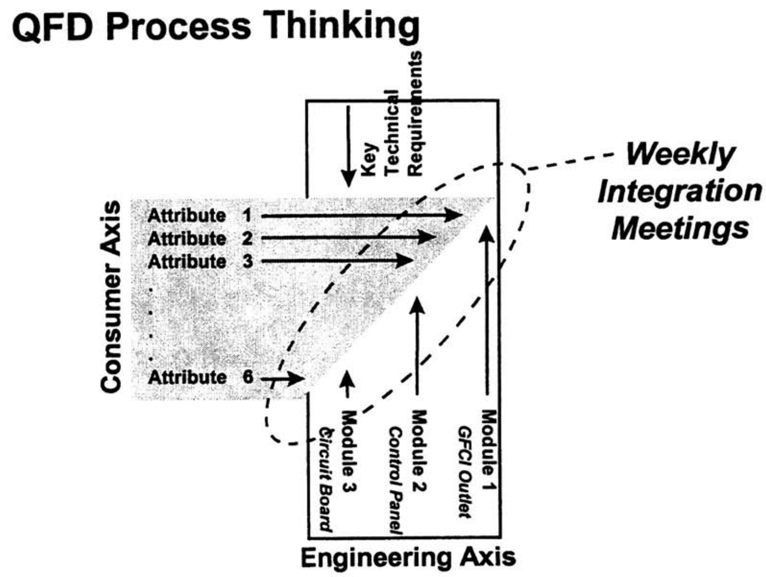

Figure 4-5 Interface Management

Because of project learning objectives and because of the relatively small team size, the lead integrator role was rotated weekly. Figure 4-5 above illustrates the general process flow from the two axis, the Consumer and the Engineer (or Component/Hardware). As can be seen from the illustration, the attribute axis meets the engineering axis during the weekly integration reviews. This is where the really good discussion took place that was very valuable in keeping the team tuned into a total product optimization mindset. Even though the hardware champions were also attributes champions, there were still module sub-optimization positions that had to be continually diffused. At the conclusion of each integration review, clear strides were made to bring all team members back to a total product optimization view. More detail on attribute championship is discussed in the following section.

Process c) Stronger Emphasis on Consumer-Focused Tools:

The predominant tool used throughout the PD process was the consumer survey. It was used three times to define the design requirements, to define the design concept details, and to verify the design. The FMEA and DVP tools were used as disciplines not only around hardware failure modes but also around functional failure modes. That is the possible areas of failure to meet the attributes performance was analyzed and recommended actions were completed to attack the high risk items. The consumer focus assisted in keeping the emphasis on the consumer.

Process d) Simplifies Consumer Driven Specification / Knowledgebasing:

One very clear fact that the team had to face was that there was no time in the twelve week course to develop and maintain detailed engineering specifications. So the team separated the regulatory musts from the consumer preference requirements. The team assigned a champion for the essential regulatory requirements that did have to be researched and maintained. Then the team discussed what method should be used for handling the translation of consumer wants into engineering requirements. What was clear from the discussion is that there was very little time to translate consumer wants into well thought out engineering specifications, that is required to achieve acceptable performance using standard translational and data-keeping models.. What was clear was the need to keep the consumer wants alive throughout the PD process, eliminating the need for most of the rigorous translation. This meant getting to know the consumer, then thinking like the consumer, and then most of all promoting the consumer wants in all the tasks. This methodology is rarely seen in large corporate product development processes due to the large complexity, and accepted practice of the engineering specification maintenance. However, with the growing build-up of

Knowledgebased data, one must ask, "Are companies knowledgebasing the right data?" That is, would it be more direct., efficient, and accurate to manage consumer data, as opposed to attempts at translation?

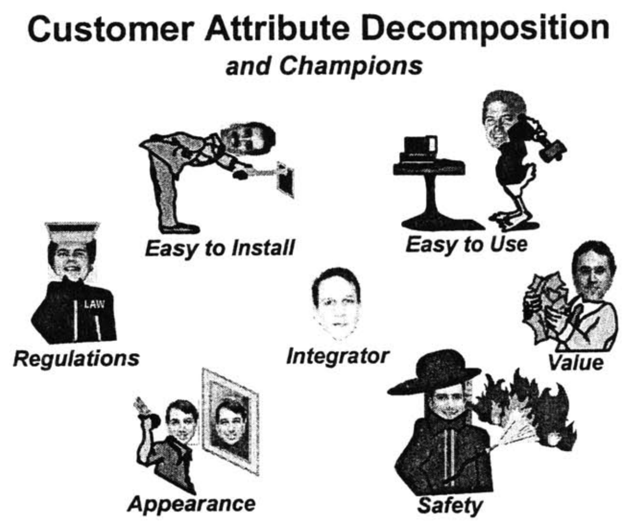

Figure 4-6 Consumer Attribute Champions

Figure 4-6 illustrates the assignment of the attributes to each champion. Because of the large cultural shift, even in a small class project environment, to get the O.K. to assign attribute champions, the thesis authors had to accept the task of ensuring the smooth execution of this methodology. The authors felt it was only fair.

Process e) Ties Program Team Directly to the Consumer:

Using the attribute champion approach outlined previously was a strong organizational approach to delivering a consumer based decomposition to the team. To make sure these champions had the best consumer want data, the team frequently went back to the consumer with surveys. This was conducted in the typical Ford Motor Company three phase representation, as shown in figure 4-7.

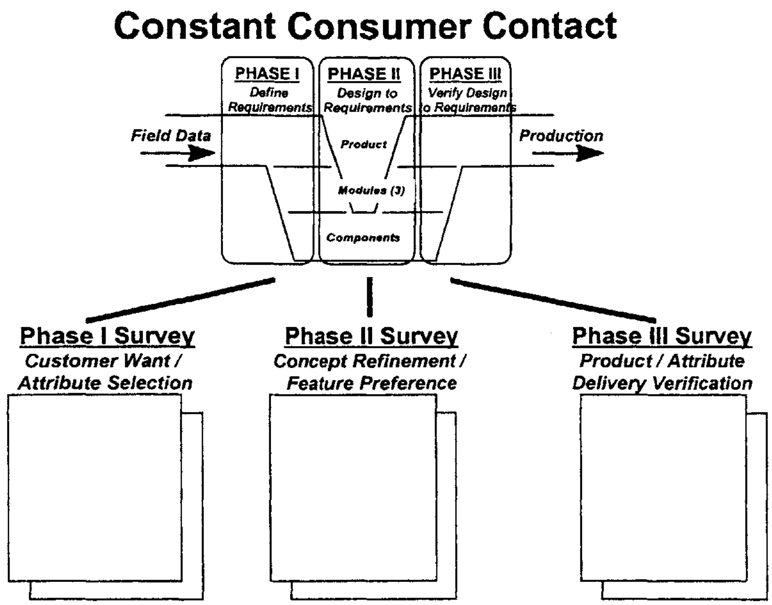

Figure 4-7 Essential Constant Consumer Link

Phase I included general, non-leading questions around the need specifically targeting attribute generation, and consumer thoughts that could lead to architecture generation. Phase II included concept pictures by which to better nail down the consumer sub-preferences. Phase III was used as a verification tool of the final product acceptance, and pricing / marketing strategy reinforcement. Most of the consumer surveys conducted by the PDD team were of prospective users that were related somehow to team members. This helped establish an informal consumer acceptability team, as seen as part of the Mustang Application Study discussed in Chapter 6, and as included as part of the final thesis recommendation. This process could be used on a larger scale for Ford program application with the establishing of consumer groups to meeting frequently with program teams. Mike Zevalkink - VLD of the Crown Victoria / Grand Marquee / Town Car platform has recommended setting these teams for his programs. Similar teams have been implemented with Mustang, T-Bird, and Light Truck teams.

Organizational Elements

Organization a) Establishes Experience:

Working to learn more about the consumer wants, the attributes champions could sub-focus their efforts specifically on their attribute. This allowed for quicker consumer attribute knowledge learning. With this pure consumer-based approach, combined with the weekly interface meetings to share the in the attribute and hardware learning, there was very little need to formally translate consumer preferences into detailed specifications. This kept documentation down to a minimum, and the product development work to a maximum. Of course the major driver for not needing a knowledgebase was the relatively minute size of this product in comparison to an automotive program. However, this approach of a strong consumer attribute championship and fully-aligned objectives could lead to that magical simplification our reduction in number of specifications that have to be developed, designed to, verified to, and of course documented and maintained.

Organization b) Enable Engineering Efficiency:

Engineering efficiency was essential, for the resources and timing that was set. The redundant use of engineers, both as module engineers and as attribute champions, eased the manageability of the weekly integration meetings. With a more complex product, this exact methodology would not be possible and therefore the integration meeting process would have to be revised by breaking apart into strong attribute teams or Program Attribute Team groupings. The consumer-based direction to the supply-base, without over specification, and the resulting flexibility in supplier business optimization would generate greater performance along with economical benefits. It would also eliminate the tendency of the OEM engineer from doing the supplier's work (shadow engineering).

Organization c) Enables Engineering Motivation / Simplifies Management Metrics:

The dual roles around consumer focus and the strong metric presence around the consumer drove the team to natural motivation to achieve consumer satisfaction. At times the 'this is just a class' thought process clouded some efforts, but with competition to be the best, this was overcome. The only 'management' metric that seemed misaligned from the consumer was the letter grade recognition of the team's PD approach and product result. An A- was achieved, which in MIT standards is very good. The issue comes up when comparing the Power-Off Timer product results and grade to other teams who achieved A's and A+'s. The A and A+ teams failed to achieve a true working engineering prototype within consumer verified targets (such as cost, function, etc.). The PDD Power-Off Timer team did achieved consumer verification to all targets, including cost, with a reliable product prototype. The team also had interest from Leviton, maker of commercial and residential electrical hardware, who did some minor consulting throughout the PD process. The real lesson is: Is the end consumer purely the only audience a product team must target performance? For example: stockholders buying a companies stock, airlines buying an aircraft, etc.

Organization d) Creates Common Consumer Focused Alignment:

Common meaning common alignment across organizations. This was not a good study of cross organizational alignment for obvious small scale reasons. The team functioned as a small organization or company with cross functional expertise.

Chapter Conclusion

Strategic Analysis:

The main difficulty in strategically applying this approach to a Ford Motor Company program is the degree of complexity difference. Having engineering function as market analysts, attribute champions, and component engineers is strategically unfeasible. The large complexities within the larger system attribute and hardware regions, demands more undivided attention. This does not mean that there could not be an adaptation of the consumer alignment to influence the hardware engineer. In fact that remains a strong part of the Chapter 2 conclusion recommendation. Chapter 2 will address some revisions to this strategy to build in the areas that deal with much larger complexity.

Cultural Analysis:

Culturally, a consumer headset methodology has been introduced at Ford. Engineers are being asked to know the consumer; to participate at the Ford Customer

Assistance Center; to experience the consumer through inspection studies; etc. Also, Vehicle Attribute Engineering activities are building up and taking a stronger role in the PD process. The VDS process is taking a more formal role in the preprogram phases. Letting go of the component engineering mindset is occurring, mostly though the attrition of the engineering component engineers. This hardware or component engineering is being passed to the Full-Service Supplier and the Ford engineer is now put in the role of a system engineer. Internal knowledge of components will be lost the supply-base forever and the slow build-up of system knowledge has been occurring for the past decade.

It was interesting how the team did try to revert to its functional chimneys. When issues arose, there was a typical electrical versus mechanical finger pointing. The consumer alignment representation assisted in keeping our solutions targeted towards the best possible for the consumer. Otherwise it may have been lost back in one of the functional chimneys.

Political Analysis:

The politics are slow in coming to the Attribute mindset. The next hurdle will to convince the Hardware or functional organizations to champion consumer attributes as was introduced in the PDD project module strategy. It may be more complex to decompose Automotive Consumer attributes to 'module' activities, but it is not impossible or a reason that should lead to dismissal of the approach. The following Xerox and Mustang cases in Chapters 5 and 6 respectively, outline examples of how to assign attributes in large complex products. In these two cases, is the illustration of the amount of focus and drive required to move against the strong reluctance to accept responsibilities where there is not ultimate control. This reason alone is the contributor to a lot of the political drag within large companies today. Granted there are questions to as to the existence of the knowledge, but if the consumer relevant knowledge is rewarded, the knowledge will come in droves. Once the championship is assigned, team management metrics need to be put in place before to reinforce the consumer alignment. Again, the Xerox case study use of 'Management by Fact' charts is a good example.

Pugh Score:

The following Pugh matrix, Figure 4-8 scores the PDD very well in the acceptance criteria areas, but fails to provide the scale to fully prove a cultural and political example of implementation of these ideas. The following Xerox and Mustang Cases do provide the required scale in Chapters 5 and 6 respectively.

Comparison Pugh

Improvement Measures	Current Tradition.	PDD Trial
PRODUCT- World's Leader in Consumer Satisfaction		
a) Decomposition ~~preserves~~ promotes holistic emotional essence	baseline	+
PROCESS Streamlines the Application of System Engineering		
a) Promotes Unified Architectural Vision	baseline	+
b) Improves Method for Optimizing Consumer Attribute Tradeoffs	baseline	+
c) Stronger Emphasis on Consumer Focused Tools	baseline	+
d) Simplifies Consumer Driven Specification / Knowledgebasing	baseline	+
e) Ties Program Team Directly to the Consumer	baseline	+
ORGANIZATION - Natural Consumer Alignment		
a) Establishes Experience	baseline	+
b) Enables Engineering Efficiency	baseline	+
c) Enables Engineering Motivation / Simplifies Management Metrics	baseline	+
d) Creates Common Consumer Focused Alignment	baseline	
FEASIBILITY OF ADAPTATION		
STATEGIC FEASIBILITY	✓	✓
POLITICAL FEASIBILITY	✓	
CULTURAL FEASIBILITY	✓	

Figure 4-8 Term Project Trial Pugh Score

CHAPTER 5 - XEROX CASE STUDY

Chapter Introduction

This case study made possible by Dr. John Elter and Shelly Hayes of Xerox, who provided extensive background information, and discussed the DocuCentre project during a meeting at their Rochester New York facility. Their cooperation is greatly appreciated.

In the early 1990's Xerox faced significant challenges from competitors and from consumers. Competition was selling photocopiers at a price lower than Xerox's cost to produce a comparable machine, and the competitive machines were equivalent or superior in quality. Consumer work processes and their corresponding duplication needs were also shifting during this time.

This confluence of drivers illuminated Xerox's need for a new product paradigm. A new marketing strategy was developed: Xerox would be known as to "The Document Company." This corporate identity drove Xerox to evaluate the consumers' work processes, and design a product to help make them more productive, and not focus solely on photocopying. Because most documents were created in a workstation and not a typewriter, there was a sentiment to shift from analog to a digital basis. The vision of a "modular, digitally optimized, extensible platform that would be a dominant design paradigm" was born.

The consumer focus that drove this vision was maintained throughout all elements of product development, manufacturing and service. The resulting product has been a great success for Xerox, in terms of both customer satisfaction and financial success. However, this did not happen by accident: significant efforts were made to maintain the consumer focus.

Product Elements

Product a) Decomposition promotes holistic emotional essence:

The resulting product promoted the essence of a consumer focused, total document processor through integration of design, manufacturing, and service strategies. The product's reliability is the best of any product in Xerox's history and it is the best in the industry. It is a modularized architecture that optimizes extensibility, manufacturability and servicability. For example, additional hardware modules can be added to the base machine in order to add features. Also, the number of spare parts was reduced by an order of magnitude, significantly improving part availability.

Customer satisfaction was over 90% in some markets, making it an industry leader. While this is impressive, the ultimate evaluation of any product is its success in the marketplace. In this regard, the DocuCentre is a significant achievement. It has generated more than a billion dollars for Xerox, with a respectable profit margin on each machine.

In regards to promoting the product's emotional essence, the DocuCentre team has been more successful than many Ford vehicle programs, but only as good as others. However, the DocuCentre success was the result of a systematic approach, giving Xerox an advantage in comparison to Ford.

Process Elements

These product results are the culmination of a comprehensive development process, that maintained a focus on the needs of the customer. The key elements of this process include the following.

Process a) Promotes Unified Architectural Vision:

The DocuCentre Chief Engineer functioned as the system architect and expressed a clear vision of the product and this remained consistent over time. As a technical expert, the DocuCentre System Architect allocated functionality to the appropriate elements, based on achieving the customer wants as efficiently as possible. Early in the development process, the architect was able to optimize these tradeoffs due to his expertise in both the functional domain and the consumer domain. These early agreements in architecture drove performance, extensibility and modularity. For example, selecting a belt paper feed over a drum feed effected durability, robustness and cost. However, because the architect was aware of these tradeoffs, these types of decisions were made early in the process, and did not need to be re-negotiated later, after development work had already begun. Later in the program, as new tradeoffs were required the system architect was again able to optimize them based on his insight to the product and the consumer.

The DocuCentre model is significantly better than the typical Ford model due to the up-front involvement of the system architect in the early target setting portion of the program. This gives Xerox a significant advantage in promoting a unified vision throughout the program.

Process b) Improves Method for Optimizing Consumer Attribute Tradeoffs:

Xerox applied a system engineering approach that optimized the DocuCentre's over all performance to the customer wants by enabling tradeoffs between systems. At a level of detail lower than the system architect, the system engineers were able to conduct tradeoffs due to their understanding of their specific system, and the contribution it makes to the overall performance of the product. In the same way as the unified product vision, Xerox has an advantage over the Ford methodologies.

Process c) Stronger Emphasis on Consumer Focused Tools:

Process e) Ties Program Team Directly to the Consumer:

Several consumer focused tools were emphasized and monitored during the product development process. Very early in the process, customer interviews were conducted, to help identify the consumer needs. A critical aspect of this step is that these interviews were conducted by members of the product development team, rather than by a remote marketing activity. This unfiltered consumer input provided deeper understanding and insight to the stated needs. Consumer interviews were repeated at various stages throughout the development cycle, which allowed feedback on specific product options, and just as importantly, reinforced management's focus on the consumer.

The DocuCentre team took a new approach in the interview process. Typically, Xerox conducted consumer research in which they asked the customer what they wanted in the next copier. Instead of this, the DocuCentre team asked consumers about their work processes, and what could be done to change / improve their them.

These interviews produced 780 "voices" of consumers that were typed up on little cards. These cards were then sent back to the consumers, who were asked to categorize the cards into categories that they thought made sense. (note that the consumers were compensated for their assistance). These categories were called "exemplars" because they summarized the needs of the consumer and provided the DocuCentre team with the voice of the consumer. Below are the 21 exemplars defined by Xerox and its customers, in no particular order:

- Professional looking output
- Can add features (modularity)
- Plug and play
- Easy to install
- Always able to transmit
- Operates at rated speed
- Fewer jams
- Knows status of documents
- Compatible with current equipment
- No learning needed
- Can diagnose problems
- Consistent output
- Does total job, finishing
- Always available
- Can route and track documents
- Can maintain to avoid breakdowns
- Ties to existing network
- Notifies when broken
- No skewed images
- Multiple jobs simultaneously
- Heavy Duty

Note that Xerox's process of organizing, summarizing and drawing conclusions from this large volume of consumer data is very similar to the Language Processing (LP) Method described by Shoji Shiba in his book A New American TQM.

These exemplars alone , however, can not be used as engineering metrics, and the team had some question of what to do with them. The classic tool used to convert "voice of the customer" into engineering requirements is the Quality Functional Deployment (QFD) which the team initiated.

During the early stages of the development program, the team held weekly functional team leader meetings. This instilled the need for communication and cooperation, and reinforced the customer focus. Over time the program grew too large and these meetings stopped, but by that time the ideas had been accepted, and the meetings were not required. Without question, this is an area of great strength for Xerox, and Ford efforts to integrate the consumer into the development process pale in comparison.

Process d) Simplifies Consumer Driven Specification / Knowledgebasing:

The DocuCentre team began with very few legacy specifications. Essentially the only criteria that they started with were technical standards, such as wiring design standards and electrical power specifications for purchased components. Given these few component performance specifications, the DocuCentre team did two things to provide product direction. The QFD and FIT tools described above were combined with the functional expertise of the FIT Champions to decompose exemplars into objective performance criteria as appropriate. These requirements were tracked on the Management By Fact (MBF) chart exemplified below, which included a description of the issue, a root cause analysis, a recovery plan, and any "roadblocks" that required management assistance. This encouraged engineers to resolve issues prior to the MBF reviews, because if there were no variations to gap, then there was no need to discuss the system, and no assignments were given.

Variance to Gap	Root Cause	Counter Measures	Process Capability
Paper jams	▪ Why ▪ Why ▪ Why ▪ Why ▪ Why	• Re-design paper feeder	▪ Need 2 man years only have 1

Figure 5-1 Management By Fact Chart

Emphasis on the "critical few" requirements allowed the DocuCentre team to benefit from this information because it prioritized the needs, and avoided the paralysis of unmanageable workloads. When it became apparent that the amount of time required to conduct a full QFD on all 21 exemplars for all components would "bring the process to its knees," the team decided to conduct full QFD's on three exemplars that effected every critical part of the machine: "Fewer Jams," " Professional Looking Output " and " Can Maintain to Avoid Breakdowns." The remaining 18 exemplars were called Functionally Important Topics (FITs). The QFD's were conducted to provide specific requirements that could be objectively tracked and also evolved into FITs. To help accomplish this, the DocuCentre team conducted specific training in the areas of QFD and Robust Engineering.

The FITs were assigned to systems engineers based on which systems had the most effect on achieving the FIT. These FIT Champions were functional system engineers because, by definition, FITS can only be managed at the system level. As experts in their system, the champions were also responsible to decompose the FIT requirement into requirements for the subsystems/components. There was no "silver bullet" to conducting this decomposition - it was accomplished through the expertise of the system engineers. The need to make complex decisions and have other activities follow them demands high qualifications for system engineers, the most important being respect within the organization because direction from the system engineers often affected other systems, over which they had no formal control.

For requirements that could not be readily decomposed, and for evaluation of the overall system, subjective metrics were used. The evaluation to these subjective metrics was done by the FIT Champion, who understood what the consumer truly wanted. There were no high-tech evaluation tools, no computer simulations - the expertise of the attribute champion made those unnecessary.

The DocuCentre's combination of fewer specifications and management by exception certainly simplifies their process, allowing it to be more responsive to consumers. However, this is not necessarily the best situation. With no "corporate" specifications to guide them, the team is able to forge new ground and prioritize according to the consumer needs. But, the team may also be repeating critical mistakes that were not adequately documented in prior programs. Additionally, the team may be spending inordinate resources in "re-inventing the wheel." Although the Ford specification and knowledgebasing systems seem to be excessive, the absence of them would be worse. Neither has an overwhelming advantage; a happy medium must lie between the two.

Organizational Elements

Early in the program, the entire DocuCentre team moved to its own dedicated building, which was removed from the rest of the company. The building was organized around the cross-functional teams that were formed. As shown in the organization chart below, the team was formally organized based on the function performed,. such as Mechanical Design. This allowed the engineers to be grouped with the other engineers with whom they would most frequently interact.

One notable element is the dedicated department for system engineering. Xerox believed it important to provide an organization to help validate this activity, and provide a source of authority to enforce decisions. The system engineers were functional experts in their given system, such as Paper Path System, and were responsible for integrating their system into the overall product and were assigned as FIT Champion for the FIT that was most significantly effected by their system. For example, the system engineer for the Paper Path System was the champion for the "Fewer Jams." The system engineers also led cross functional teams that included hardware, software and electronic design engineers but these engineers did not officially report to the system engineer. As a result, the system engineers often made key decisions, but had little formal control. The presence of a system engineer for each major subsystem provided a system engineer on each side of an interface, overlapping the expertise of an issues, and assuring that the interests of each system were considered. The generalized organization structure utilized by the DocuCentre team is shown below in figure 5.2.

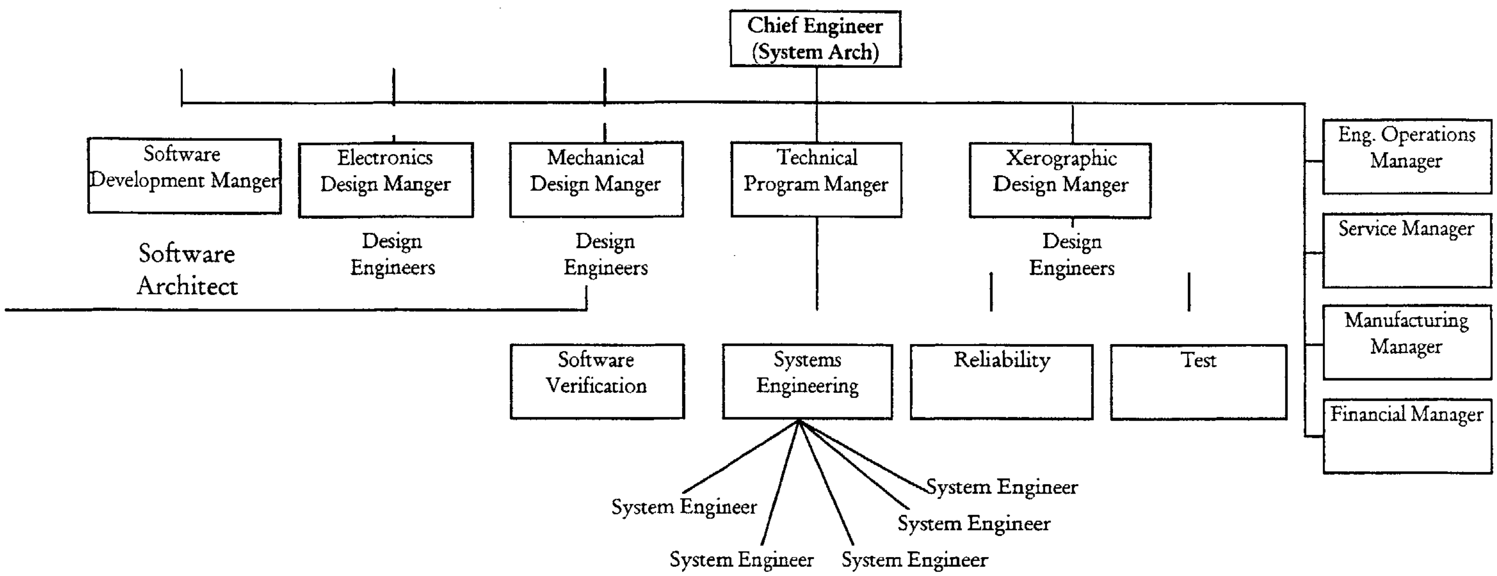

Figure 5-2 DocuCentre Organization Structure

Organization a) Established Experience:

The DocuCentre team provided its members with several tools, and provided consumer inputs to help them understand the real needs the product must satisfy. However, there did not appear to be any concerted effort to cross-train or build experience making the DocuCentre program much like Ford vehicle programs.

Organization b) Enables Engineering Efficiency:

As described in above in the above section Process: Simplifies Consumer Driven Specification / Knowledgebasing, engineering efficiency was not a benefit of the DocuCentre program. With early Chief Engineer involvement in the target setting process, program direction was agreed upon early. This reduces churning of assumptions and changes in direction that drive a lot of inefficiency at Ford. However, with minimal corporate specifications, there is significant potential for "re-inventing the wheel" and repeating mistakes. These will require significant re-engineering and drive inefficiency. Overall, these two aspects equalize the engineering efficiencies of the DocuCentre program and Ford.

Organization c) Enables Engineering Motivation / Simplifies Management Metrics:

The motivation of DocuCentre engineers was enhanced by the direct involvement of consumers, and by a strong, consistent vision of the product, which proved to be a valuable asset. There are several stories of engineers making significant sacrifices to support the team. Management metrics, however, did not seem exceptionally simplified. The Management By Fact chart described earlier tracked multitudes of requirements. These metrics, though, were developed within the team, allowing them to be more flexible and providing ownership. Additionally, the rationale behind the metrics was clearly understood, allowing effective tradeoffs when conflicts arose.

Ford does not involve consumers directly, and the product vision changes over time on some vehicle programs. However, many vehicle programs consistently communicate the program vision to the engineering activities, which are still well motivated. Unfortunately, they are motivated to satisfy the multitude of metrics that Ford tracks, similar to Xerox. Although there are some advantages, overall, the DocuCentre program does not have inherent processes or organizational element that significantly improves engineering motivation or simplifies management metrics. If

Ford metrics were more consumer oriented, our vehicles would be as satisfying as the DocuCentre - additional engineering motivation is not required.

Organization d) Promotes Unified Architectural Vision:

The organization chart also shows that the team included design, manufacturing, and service activities. This was key in developing a new paradigm that looks at the entire ownership experience. The alignment of other activities, not shown on the chart, was also key. Because this was a clean sheet design, and because the product content was driven by the customer and not by the list of existing in-house expertise, many new technologies had to be developed specifically for this product. This required the commitment of research people to develop new expertise. Additionally, service technicians, promotional and other activities were also aligned to communicate the vision of the product to the consumers. Overall, this alignment improved the efficiency of the process, with R&D producing the right technologies at the right time, the development team validating and implementing these new technologies, and consumer-contact activities promoting the exact messages that the product was designed to meet.

Other organizational elements are not apparent on the chart, but are just as important. For example, the practice of focusing on the vital few issues was key to efficiency and quality of work. This was made possible through the use of a standard proforma for report out that was simple and efficient. The Management by Fact chart, described earlier, tracked the status of each metric, identified any variance, and described the root cause and resolution plan. This process essentially "automated" status reporting, and only items with significant variances required discussion.

Another key element that is not apparent on the chart is the strong leadership from the top. The chief engineer provided strong and consistent direction, over and over. Eventually, issues could be resolved without having to elevate them through management because everyone knew what the chief would say.. This also supported the system engineering efforts, as they were sometimes in need of support to implement difficult, cross-system decisions.

The DocuCentre team was able to successfully develop a consumer focused product, but this was primarily the result of strong top-down leadership that was able to drive resolution of issues. Because the FIT Champions were not directly responsible for the design and release of the components, they had to coerce the release activities to deliver the exemplars. This is a significant weakness in the DocuCentre organization.

Chapter Conclusion

Strategic Analysis:

Key strategic elements include the following: functional strategies came out of the voice of the customer, and not the current capability of the organization; the DocuCentre team did not limit their product scope to the areas in which they had established technical expertise. Instead, the needs of the customers drove the selection of technologies, and Xerox then developed the required expertise.

The qualifications for the role of System Engineer were held high; an engineer had to be experienced, knowledgeable and proven. These high requirements provided the system engineering with both a direct benefit of highly skilled people, and an indirect benefit of positive reputation for the organization. In order for this system to work for Xerox, an established pool of system engineers was needed. Without this, a more rigorous set of specifications would be required.

Design engineers did not spend excessive time reporting to management. Essentially all metrics were tracked on a standard proforma, and only the significant issues were raised to management's attention. This allowed the engineers to focus on the product design.

Cultural Analysis:

The DocuCentre team was able to effectively shift its culture. This was accomplished through effective communication as well as other efforts. The chief engineer repeated his messages "again and again and again, because people forget and forget and forget." Additionally, the messages were consistent over time which improved retention, and also increased their legitimacy.

The team was instilled with an entrepreneurial spirit, which also supported the customer focus. The design engineers were told to run their job like it was a small business. For example, one individual's job was to run a fusing business, not do design a fuser. Running a fuser business means knowing what your (immediate) consumer needs, and working to satisfy them. This is more demanding than simply designing a product to meets requirements and handing it off to another engineer.

Changes in the DocuCentre team culture was aided by a high regard for the individuals on the team. They developed an employee "bill of rights," and employed "managing from the heart". These concepts reflect the people-oriented atmosphere of the team. As a result, employees were self-motivated by their allegiance to the team, and by the strong product vision that had been communicated to them.

Political Analysis:

The DocuCentre team had a very strong Systems Engineering organization that reported to a single manager and were not sprinkled throughout the organization. This provided them an organizational identity similar to the identity shared by functional organizations, and improved communication and reporting. However, because the system engineers lacked design authority, they could only affect product design through coercion, or by raising issues to management.

In later attempts to duplicate the success of the DocuCentre team, some of these efforts have faltered. Team buildings are no longer organized around the Multi-functional teams because functional organizations began to play a greater role in the corporation, and they have a different perspective on the role of Multi-Functional teams. Unfortunately, this is likely the scenario that Ford would fall into if it implemented such a plan. With those responsible for the "voice of the customer" not responsible for the design and release of parts, and with the primary focus on cost, weight and timing, it is very difficult to have parts designed to subjective consumer metrics.

The DocuCentre management formed partnerships with the senior Xerox management, and shared ownership of the program with them. This established support when barriers were found, and also helped the team maintain focus by preventing outside influences from changing direction. This is key to establishing a unified vision of the product.

The DocuCentre team started with a "clean sheet", meaning that there was little need for maintaining commonality with existing technologies, components, or manufacturing facilities. This is typically not the case for manufacturing based companies, which must maintain commonality to achieve affordability. The DocuCentre was not constrained by these requirements due to the nature of the duplication industry, the newness of the technology being applied, and because the project had senior level champions, who shared the product vision. As John Elter said "I think you have to go the top, when you are doing a clean sheet" because new paradigms require support to break down old barriers. However, it is difficult to start at the top and work your way down when architecture and components are legacy designs; which drives bottom-up engineering. As a result these issues, direct application of the DocuCentre model would not be politically feasible at Ford.

Pugh Score:

The matrix below summarizes the above comparisons of the Xerox case and the current Ford product development practices. As this matrix shows, Xerox offers improved practices in several areas, and will be used in the development of this thesis' recommendations.

Comparison Pugh

Improvement Measures	Current Tradition.	Xerox Case
PRODUCT- World's Leader in Consumer Satisfaction		
a) Decomposition ~~preserves~~ promotes holistic emotional essence	baseline	+
PROCESS Streamlines the Application of System Eng.		
a) Promotes Unified Architectural Vision	baseline	+
b) Improves Method for Optimizing Consumer Attribute Tradeoffs	baseline	+
c) Stronger Emphasis on Consumer Focused Tools	baseline	+
d) Simplifies Consumer Driven Specification / Knowledgebasing	baseline	=
e) Ties Program Team Directly to the Consumer	baseline	+
ORGANIZATION - Natural Consumer Alignment		
a) Establishes Experience	baseline	=
b) Enables Engineering Efficiency	baseline	=
c) Enables Engineering Motivation / Simplifies Management Metrics	baseline	=
d) Creates Common Consumer Focused Alignment	baseline	+
FEASIBILITY OF		
STATEGIC FEASIBILITY	✓	✓
POLITICAL FEASIBILITY	✓	—
CULTURAL FEASIBILITY	✓	✓

Figure 5-3 Xerox Case Study Pugh Score

CHAPTER 6 - MUSTANG APPLICATION STUDY

Chapter Introduction

The 200X Ford Mustang will be a continuation of what has been termed, "A Pony-Car Icon." The product will incorporate evolutionary improvements to performance, reliability, environmental accountability, and value. From its heritage, the Mustang embodies vitality and personal freedom, and crosses multiple demographic segments. Introduced in 1964, the Mustang was an instant success, with model-year production peaking at over 600,000 vehicles in 1965. Mustang pioneered the "pony car" concept with a long hood / short deck silhouette, bucket-seat interior, floor shifter, and a wide range of powertrain options. The Mustang satisfied many consumers, from the value-conscious to the performance-focused. The 200X Mustang will continue the tradition of the Mustang and will deliver the product under FPDS.

The Chief Program Engineer (CPE) adopted a consumer approach to develop the 200X Mustang within the Ford Product Development System (FPDS) framework. The 200X Mustang is the first Ford team to apply an attribute-focused process similar to the recommended solution proposed by this thesis. Because of the similarities in vision between the Mustang CPE and the thesis authors, the 200X Mustang is an interesting preview of the issues and opportunities related to "enabling a consumer headset."

From a process standpoint, the early phase of the Mustang program concentrated on defining the appropriate attributes to characterize the 200X Mustang and established a tracking matrix to understand the impacts, relationships, shortfalls, and key hardware contributors needed to successfully deliver the customer attributes. From an organizational standpoint, the 200X Mustang identified Attribute Team Leaders to focus on specific attributes. These Team Leaders report to the key Vehicle Chunk Managers who in turn report to the CPE.

A note about the 200X Mustang team: since this is the early phase of the product's development, the process and organizational mechanisms applied are nascent and have yet to be fully evaluated over an entire program life. Ford has historically been very adept at pilot implementations and fragmented executions, only to discover the true intractable nature of establishing a new mindset practice. The attribute focus initiated in the Mustang program is a subset of the broader Ford matrix organization alignment and cultural norms.

Product Elements

Product a) Decomposition promotes holistic emotional essence:

The architecture of the 200X Mustang was defined to continue the rear-wheel drive powertrain configuration which is a hallmark of the "muscle car" vehicles produced in the 1960s. The CPE of the Mustang applied an attribute focus to the product by establishing and staffing Attribute Leaders. The Ford template of 15 attributes was used as the preliminary decomposition method for consumer input. Later, as the program progressed and a deeper understanding of a "mustang customer" emerged, the 15 attributes were revised to encompass the unique characteristics of a Mustang. This expanded the attribute set to 22. A key feature of the attribute decomposition, similar to the thesis proposal, was the organizational alignment of the Attribute Leaders on the team. The Attribute Leaders were assigned to the respective program functional chunk managers (Program Module Teams) based on the predominant influence the hardware had on the success of the attribute. This established the reporting relationships illustrated in Figure 6-1

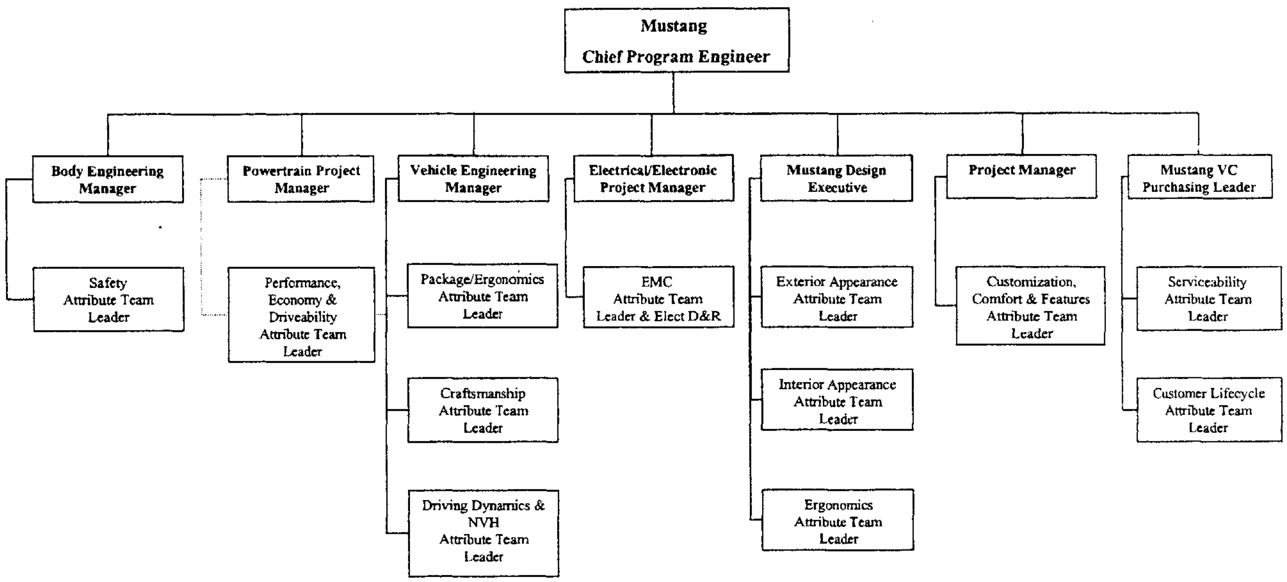

Figure 6-1 Mustang Attribute Leader Reporting Relationship

Two features of this structure go beyond Ford's current use of attribute engineers: 1) Aligning Attribute Leaders to functional Managers; and 2) revising the Ford template of attributes to capture the essence of Mustang customers. This attribute organizational structure is a subset of the whole 200X Mustang Team. The companion to this organization is the support team of Design & Release, Finance, Testing, Manufacturing/Assembly and respective program management.

While creating the position of Attribute Leaders is no guarantee of improved consumer satisfaction, the thesis authors believe this is a critical step in Ford's recognition of the importance of Attributes, and the beginning of a shift in emphasis from a hardware decomposition to an attribute decomposition.

Beyond establishing attribute leaders, a significant part of understanding customers is in the exploration of lead users and owners of competitive products. In the area of lead users, Mustang is one of the few products within the Ford family that has a loyal customer following, mainly in the form of the Mustang Owners Clubs. These clubs are homegrown efforts organized by enthusiasts to kindle interest in Mustang vehicles, from classic to current models. In this sense, these clubs are populated with "nameplate loyal" lead customers of future Mustangs, providing an excellent source of customer input. On the competitive side, owners groups for Camaro / Firebird, BMW, Mazda Miata and Porsche possess key information on these competitor products to the Mustang. Until recently, Ford had not realized the full value of these groups as providing fundamental input to product development and contributing to ongoing loyalty preservation. Surprisingly, this model has been perfected by another American icon, Harley Davidson, through the corporate-sponsored Harley Owners Group (H.O.G.). Recognizing the value of owners-group feedback, the 200X Mustang team is committed to obtaining the input of owners clubs by informally seeking the input of these owners outside of the normal Ford Marketing / Brand Profiler process.

Process Elements

Ford created the Ford Product Development System to incorporate a Systems Engineering practice and build upon the World-Class Process / Concept-to-Customer orientation, in order to emphasize the consumer and further clarify the requirements of a new vehicle program through the course of vehicle development. The FPDS emphasizes the establishment of, and management by, targets – sequential freeze points of key vehicle geometry; also, it labels key gateway events to assess the health of the program (in essence a sequential task-driven flow). The overriding emphasis of FPDS is a structured process focused on key events that pace the program development. Essentially, it defines what is to be delivered, and when. FPDS attempted to define the processes employed to manage the program; however, the tools used to deliver the hardware are just now becoming a reality (C3P, WEB Knowledge Base, Vehicle Design Specifications, AMADEUS, Analytical Hierarchy Process).

Process a) Promotes Unified Architectural Vision

The approach employed by the 200X Mustang team is best illustrated by the information target-setting process illustrated in the following diagram, Figure 6-2: Mustang Target Development Process.

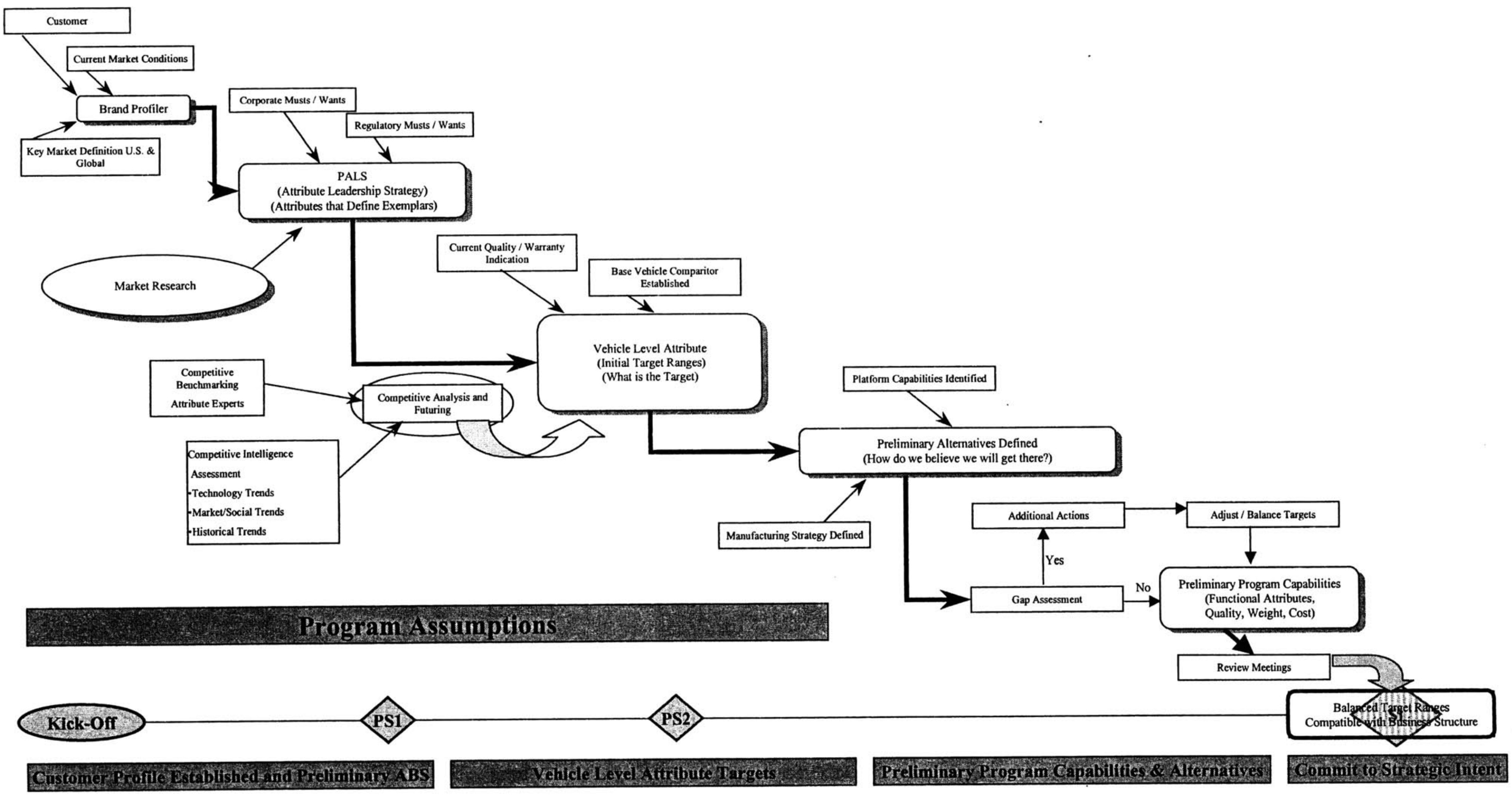

Figure 6-2 Mustang Target Development Process

The Vehicle Engineering activity of Mustang 200X team realized early that the level of detail outlined by FPDS was tremendous, and that to sufficiently manage the early phase of the program a simplification to the FPDS process in flowchart form would need to happen, to help with understanding and communication. Through various discussions with FPDS Best Practice owners, the team developed a simplified process flow. Figure 6-1 shows this basic flow, which was used as a visual beacon for each attribute owner to internalize. The Mustang Target Development Process Illustration identifies the broad activities required to get from initial customer input (needs / wants) to Strategic Intent, with a complete set of compatible business and functional targets for the program.

[Dan has asked for a specific example of targets at several levels. Show a decomposition for one or two targets.... I believe the VDS to SDS cascade diagrams would do this, but what about Proprietary issues?????]

The process begins with information obtained from the Brand Profiler analysis. Brand Profiler is Ford's version of the basic "voice of the customer" organized into a matrix form by attributes that describe a profile of the product attributes required to support Brand Positioning. Typical inputs to the profiler come from Marketing, Customer Clinics, Focus Groups, and Questionnaires. Brand Profiler is a product of the Vehicle Center Marketing Plans and Brand Development activity and is provided as a service to the Vehicle Teams. Unfortunately, the process of obtaining customer needs input is organizationally separate from the program development engineers. This is apparently a matter of necessity and efficiency because customer input occurs prior to full program engineering staffing. Also, functional expertise in the area of customer needs capture provides certain efficiencies and consistency with customer interview techniques, data compilation, and analysis. Because of this organizational separation, product engineers are isolated from direct customers. As noted in Chapter 2, it is advantageous to allow the engineer who establishes the specifications to have unfiltered direct interaction with customers, in order to mitigate translation problems. This can be accomplished by integrating a small marketing team within the Mustang team that coordinates and facilitates customer focus sessions with the Attribute Leaders and Engineers. This would have a similar purpose to the method Xerox employed with the Voice of the Customer Exemplars, as described in Chapter 5. Recognizing the critical nature of direct customer input, the Mustang Team has taken the initiative to speak to customers and obtain key development information without marketing support.

Process b) Improves Method to Optimize Attribute Tradeoffs:

The Brand Profiler, along with another key document, Initial Program Assumptions, feeds the fundamental program strategy called the Program Attribute Leadership Strategy (PALS). This is the stage at which there begins a merger of Corporate Requirements (platform reuse, carryover part content, image, brand positioning, business strategy, long term cycle strategy), Regulatory Requirements (safety, emissions) and customer needs (customer attributes) into the 15 Corporate Attributes. PALS provides the initial direction (subjective weighting factors) for the vehicle in terms of leading and/or competing with the target segments at the future launch point. These attributes are a mixture of customer functional performance discriminators and Corporate process management metrics. By conducting a few owners club interviews and relying on past experience, the Mustang 200X team realized that the 15 template Corporate Attributes did not adequately describe the Mustang in certain key discriminator categories, and grouped unique discriminators in oversimplified categories. As an alternative, the Team developed a tailored set of attributes for the Mustang. Key attributes that were introduced or modified included: 1) Customization (the ability to modify powertrain, suspension, interior); 2) Craftsmanship (separated from Styling/Appearance); 3) Performance (separated from Performance, Fuel Economy & Driveability), 4) Package and Ergonomics (which were separated); and finally 5) Fuel Economy (distinct from Performance, Fuel Economy & Driveability). The team believed this tailored set of 22 Attributes was a much more customer-focused categorization of a Mustang and captured unique key functional capabilities. As noted by a 200X Vehicle Engineer:

> ...On Mustang program there is an attribute called "Customization"... it is extremely important and a huge customer want. And we invented the attribute called Customization because of the recognized need from our internal customer research. We went out and talked to people, we learned that a high percentage of Mustang owners do something to their car after they get it. The ability to personalize their cars.

Unfortunately, this attribute departure also creates certain voids in the availability of raw data, since the Brand Profiler was not arranged in this manner. Team Mustang must rely on their own understanding of Mustang customers to provide the necessary data.

The Program Attribute Leadership Strategy is then placed in context of competitive vehicles, which have been "futured" to the Job 1 time frame. In the case of the Mustang, a competitive vehicle like a Camaro is evaluated against the Program Attributes.

Then a trend / technology assessment is made to determine the rating for a Camaro against Program Attributes in the year 200X. PALS, Futuring, and Program Assumptions are the fundamental inputs to establish target ranges for the 200X

Mustang. These targets were established independent of hardware and were based on competitive positioning, regulatory environment, and business drivers.

Process c) Stronger Emphasis on Consumer Focused Tools:

With a set of 22 attribute targets, the Mustang team is currently in the process of evaluating compatibility between attributes and assessing the position of the 200X Mustang to the targets (establishing the Gaps). The primary process tools used to support these actions are simple matrix illustrations (similar to Pugh analysis) and graphical representations. The Attribute Targets & Status illustration (shown on Page 6-3) is a powerful graphical representation of the competitive target status of the 200X aligned by attribute. The Attribute Target illustration is similar to a competitive map of the segment decomposed by attributes. This graphically depicts where the attribute leaders have established target ranges for the 200X and how those targets compare to "futured" vehicles. Overlayed is the current status of the 200X based on the understanding of hardware assumptions. The base vehicle for comparison is the current 1999 Mustang, which is labeled 100 or termed the "Comparitor." An example to clarify the illustration is NVH. As shown on the NVH row, the region corresponding to uncompetitive NVH performance for the V6 Coupe in the year 200X is from 98% to 101% relative to the current production V6 coupe; the competitive range is from 100%-102%; and a leadership position in NVH would correspond to a 105% - 107%. The proposed NVH target range for the 200X Mustang is 105%-110%. Based on the known components, systems, and the current state of the design (mainly outlined by the Program Assumptions), the 200X Mustang will meet its intended target. Some attributes also indicate where a current benchmark leader is relative to futured targets. In this case, the VW Golf I4/Manual Transmission is considered the benchmark today. Each Attribute Leader is responsible for obtaining and synthesizing the data to derive the bars.

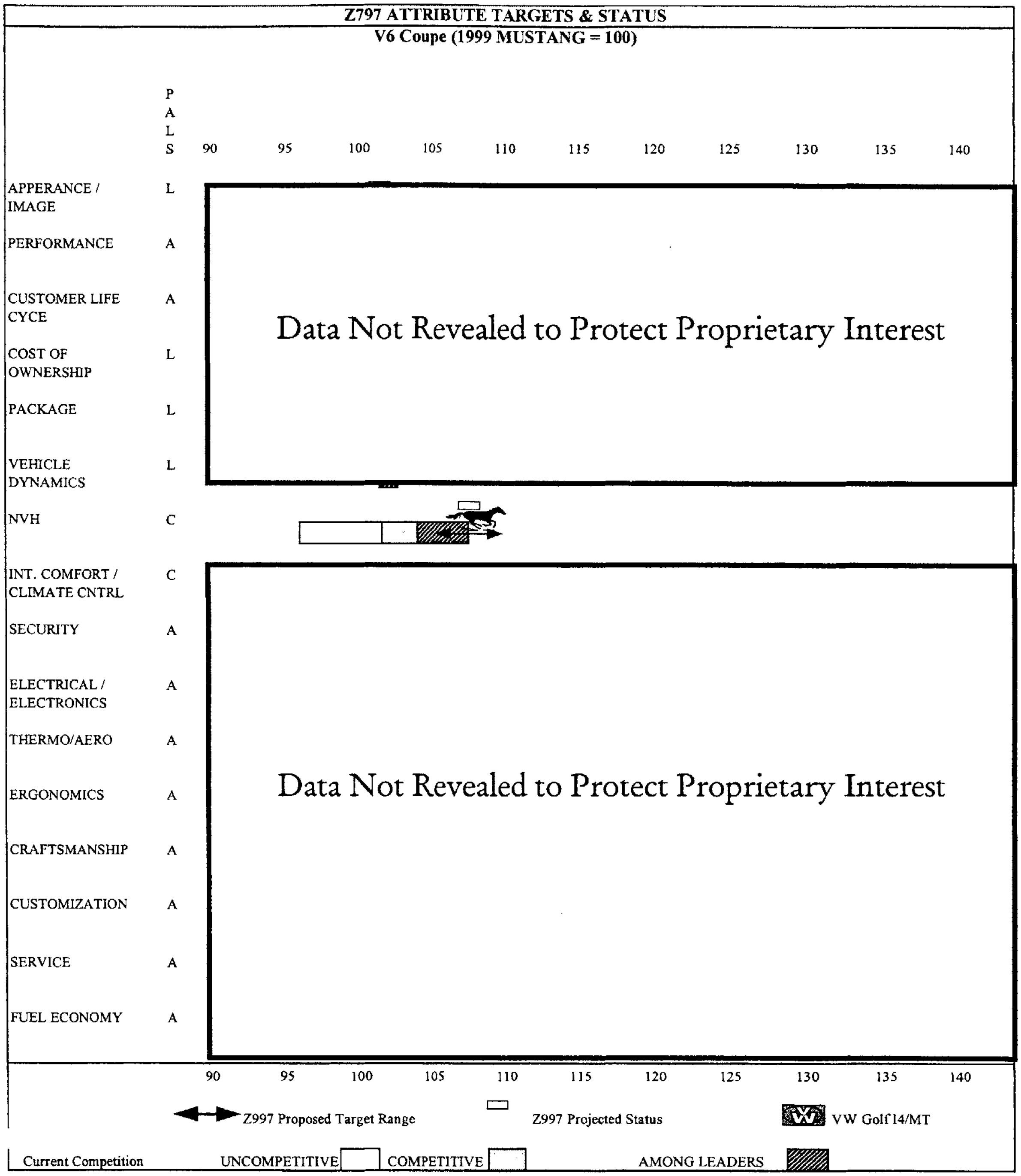

Figure 6-3 Mustang Attribute Targets and Status

Another representation of this data is in the matrix, which offers greater detail and the capability to manipulate it mathematically. The illustration (Figure 6-4) of the Program Target Matrix is the format used by the 200X Mustang team.

Program Target Matrix - 200X Z457 V6 Coupe

	Attribute Rank Order	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17		Weight	Cost			Quality		Function	Cost	Cost + Inv
	Attribute	Appearance/Image	Performance	Customer Life Cycle	Cost of Ownership	Package	Vehicle Dynamics	NVH	Interior Comfort/Climate Control	Security	Electrical/Electronics	Thermal/Aero	Ergonomics	Craftsmanship	Customization	Service	Fuel Economy	Product/Process Design Compatibility	Weight (lbs) W	Cost (US) $	Investment ($MIL, US)	Assembly Labor Time (min)	$ Cost per Unit (CPU)	TGW Things Gone Wrong	Total Function	Value = (function / cost)	Value = (function / cost+invest)
From PST/MKT	**PALS***	L	L	C	C	A	A	A	C	C	C	A	C	A	A	A	A		100.00								
From PST/MKT	**Weighting Factor**	15	15	4	10	6	18	3	2	4	8	2	5	5	3	3	5	←	PERCENT								
PAT Input	BENCHMARKING																										
	1999 Acura Integra		102	120				105			96		101				109				Volume						
	1999 Camaro (V6)		100	102		96		98					101			103	103										
	1999 Chrysler Sebring			100		110					103		101			101											
	1999 VW Golf (I4)		98			105	101	105			101			123			97				Yrs Amort						
	Toyota Solara		100	117																							
	1999 Mercury Cougar		98	93		105		99		140							102										
	Honda Prelude			108																	Asy Rate / min						
	BMW 328i			122										125													
	Toyota Celica			117																							
	COMPARATOR (1999 Mustang)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100										
	FUTURED VEHICLE TARGET																										
Calculation	TARGET GAP [B/(W)]																										
	TOTAL BOOKED RATING CHANGES																										
	PROJECTED BOOKED TARGET STATUS																										
	BOOKED TARGET GAP [B/(W)]																										

Base Assumptions
All new floorpan
Include convertible brace in coupe
16 Inch Wheels (V6)
New bumper beam
Etc.

Figure 6-4 Mustang Program Target Matrix

The benefits of the matrix are clear in the capability to evaluate / categorize data along 2 axes. Items of note in the Program Target Matrix include the Weighting Factor row, which is a directional translation from the PALS rating levels and can be used to modify other factors; the current numerical assessments of competitive / comparitor vehicles; estimation of "Futured" target; and, most importantly, a gap identification. The Mustang team identified two levels of gap: the first level is the gap of the comparitor vehicle to the future targets (frames the context of how far you need to go); the second level is the gap of the booked hardware assumptions to the future targets (indicates your current position based on hardware assumptions). Other information captured on the matrix includes the traditional cost, weight, investment, and quality metrics. An interesting dilemma surfaces as the Mustang team attempts to understand the gaps to target, as explained in the next section.

Process d) Simplifies Consumer Driven Specification / Knowledgebasing:

Evaluation of existing products based on attribute categories is simple when the products exist and can be tested via correlated / repeatable test methods. The competitive vehicles identified are purchased and tested along with the comparitor to establish the performance in attribute categories by experienced attribute leaders and team members. Unfortunately, when predictions are developed to indicate the future competitive position along two independent variables, implicitly the assessment is made from understanding both the historical trends and the nature of the hardware or technology realm. This implicit understanding of hardware capabilities is fundamental to understanding the basis of Product Assumptions. As mentioned earlier, Product Assumptions are created early in the program life and establish an array of constraints/direction for the program. Everything from target segment to brand strategy to safety enhancements to emission performance levels are included in the assumptions. Product Assumptions are driven by high-level corporate product strategy and form the principal deployment mechanism to implement cycle plan strategies.

A key portion of Product Assumptions is the identification of New and Carryover systems. These are defined in hardware / technology terms and organized by the traditional functional organization method (Corporate Product Systems Classification). In effect, the assumptions establish the preliminary functional architecture for the program. As the 200X Mustang team progresses to establishing balanced targets compatible with the affordable business structure, an assessment is made based on the hardware/technology contained in the assumptions to establish the gap to targets. From a practical standpoint, evaluating "where a program is" relative to attribute targets requires an evaluation of the proposed hardware's ability to meet the target.

A hypothetical example explains the dilemma. One small sentence of a product assumption directs "to include an independent rear suspension in the 200X Mustang modified from another 2001 Ford product." The current design may be a fixed rear axle. To establish a current status of the 200X Mustang to deliver a Vehicle Dynamics target, an assessment must be made of the independent rear suspension's capability to improve Vehicle Dynamic performance from the existing design. This assessment should be made by experienced ride/handling/suspension engineers who understand the hardware realm and can predict Vehicle Dynamic performance. The intended practice at Ford is to emphasize attributes independent of hardware early in the program, and permit the attribute targets to drive the functional architecture /

hardware definition. Targets are established through a combination of customer, benchmark vehicle inputs and business requirements and are intended to be solution-neutral.

As described in the rear suspension example, a customer need for "great cornering ability" could be correlated to an instrumented benchmark vehicle to establish engineering targets that achieve this requirement. These targets would then drive a decision for certain rear suspension configurations based on possible alternatives. The actual physical system / components selected should be made by knowledgeable chassis-suspension systems engineers. Unfortunately, actual practice is somewhat different. Program assumptions are written in system/subsystem hardware form (e.g., include convertible brace, new intake manifold, etc.). This forces the team to evaluate these line items in the physical hardware domain and make an assessment to accept or reject the assumption with appropriate explanation. At the earliest stages of the program life, the Mustang team is forced to assess and reconcile the systems / subsystems / components contained in the assumptions. At the early stage of Program Kickoff to Strategic Intent, many of the engineering teams are not fully staffed, creating a void when specific system / component expertise is required to assess capabilities to meet targets and negotiate an affordable business structure. Since FPDS requires targets and an affordable business structure by the Strategic Intent stage, a combination of attribute leaders and functional design leaders must struggle to rationalize the Product Assumptions and filter out incompatibilities. This illustrates the reinforcing mindset at Ford, created by the system / component focus of Product Assumptions, which prematurely define functional architectural solutions early in the program definition phase. As described by Sobek et. al.

> Many U.S. managers balk at the idea of wasting time and resources on ideas or projects that never reach fruition or are thrown away. And engineering processes we've observed in the United States tend to converge quickly on a "best guess" and then test it to see if it works. It usually doesn't so the iteration begins. This is the form of Point-Based Concurrent Engineering.
>
> ...Toyota's engineers and managers delay decisions and give suppliers partial information, while exploring numerous prototypes. Toyota designers think about sets of design alternatives, rather than pursuing one alternative iteratively. They gradually narrow the sets until they come to a final solution. [The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster, Ward, Liker, Cristiano, Sobek II]

As mentioned, Product Assumptions are the output of cycle plan strategies and receive input from multiple technology planning / early program analyst planning activities. This explains the resulting fragmented and incompatible nature of Product Assumptions. A possible solution to premature hardware selection is to reduce the hardware-specific references in Product Assumptions to allow the functional architecture to be driven by attribute targets. Ideally, Production Assumptions would only contain essential Corporate strategies for platform reuse, carryover systems, and product positioning. Also, Product Assumptions can define the implications to attributes and the flexibility allowed by a program to follow the Assumptions.

Another unfortunate result of detailed Product Assumptions in the early concept phase is the restrictive nature imposed on the program. This limits the efficiency and freedom of a capable Chief Program Engineer to truly architect the vehicle in the best interests of the consumer and the corporation. The CPE spends an equal amount of time disputing or rationalizing assumptions compared to exploring creative functional architectures for major systems. This inefficiency is mirrored down the program organizational structure as functional engineers provide expertise to support the rationalization of Product Assumptions.

Process e) Ties Program Team Directly to the Customer:

As noted earlier, the 200X Mustang team implemented dedicated Attribute experts to champion the development of attribute targets and facilitate the balance of attributes to deliver a whole vehicle. The attribute leaders were staffed early in the program life and to the extent possible worked with Marketing / Brand Profiler to understand the Mustang customer from the perspective of 22 attributes. The Ford template of 15 attributes was tailored to fit the characteristics of a Mustang customer and preserve the emotional essence of the vehicle. Additionally, Program Managers and Attribute Leaders individually reached out to Mustang owners and developed deeper relationships with various owners clubs and affiliated after-market equipment manufacturers.

Organizational Elements

Earlier, a subset of the Mustang organizational structure was introduced to identify Attribute Leaders as a structure to support the process of emphasizing attributes. On the 200X Mustang Team, Attribute Team Leaders are entry-level management positions / supervisory positions. The organization structure for the 200X mustang is shown below. (TITLE: Team Mustang Organization)

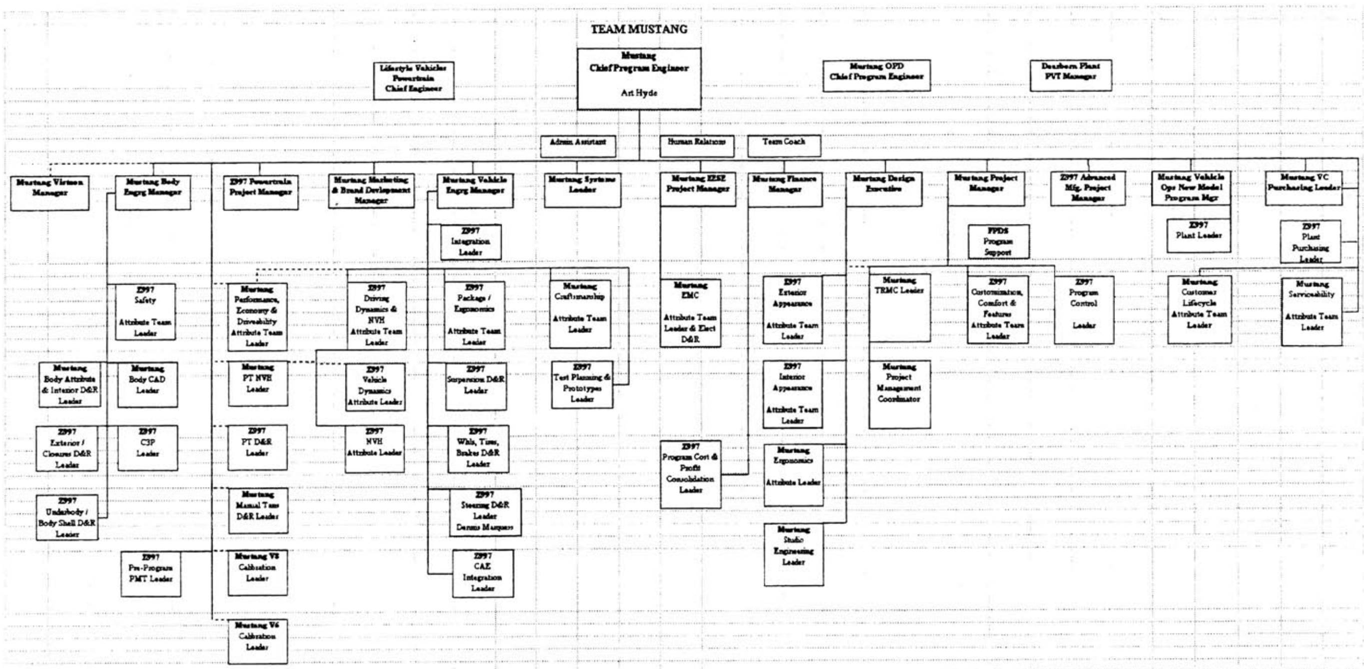

Figure 6-5 Mustang Team Organization

Some of the salient features of this organization:

- Identification of specific Attribute Leaders, especially for the non-standard template Attributes (Customization, Driving Dynamics, Craftsmanship, Separation of Package and Ergonomics). This helps to tie a portion of the team directly to the customer.
- Emphasis on the attribute ownership compared to Design & Release (D&R) responsibilities. (15 Attribute leaders to 7 Design & Release Leaders). This is a fundamental shift in traditional priorities of a program. In the past most programs were staffed with 12 Design & Release leaders and 1 Attribute Coordinator.
- Separation of Attribute Leaders from Design & Release leaders. This permits the performance objectives of the attribute leaders to be directly tied to customer needs.

The Design & Release leader's objectives are written to deliver physical systems/components.

- Attribute leaders dual-report to Program Managers and to the Chief Program Engineer.
- Integration of current Mustang responsibilities and forward model Z997 Mustang responsibilities all reporting to the same Chief Program Engineer.
- Intent of the program to retain the Attribute leaders throughout program development to launch Job 1.

Organization a) Establishes Experience:

The significance of this organizational structure is the pioneering approach to Attribute Leaders and the de-emphasis of Design & Release in the early stages. Attribute Leaders are in place, developing targets, understanding their specific attribute cascades with hardware leverage points, struggling through the balance / compatibility task of attribute targets and Product Assumptions, and working with Brand Marketing or conducting their own surveys to prioritize the needs of the customers. To promote communication and coordination, the CPE manages a weekly leaders meeting to review status and address program issues. At face value, this is the appropriate structure to emphasize Attributes. Unfortunately, a deeper investigation of the structure uncovers areas for improvement.

Organization b) Enables Engineering Efficiency:

While the Attribute Leaders are identified on an Organizational Chart with reporting relationships, a majority of these leaders are matrixed to the 200X Mustang team.

They have a matrixed organization (not shown in Figure 6-5) that develops a portion of their performance reviews, amount of merit raises, and their next assignment. These matrixed leaders are "dedicated" to the 200X Mustang and essentially spend a majority of their time on the program, but behaviorally they also respond to their home organizations. In light of its infancy, the roles and responsibilities for the attribute leaders have not been formally established, internalized, and universally supported by the matrixed home organizations. Resolving this is a primary concern to the team, and should be done early in the program to avoid boundary / scope issues and accountability concerns later. Accountability and Responsibility are the essence of ownership. An example of this conflict was the recent attempt by the 200X Mustang team to functionally decompose the attributes and identify the predominant impact traditional functional hardware will have on the respective attributes. 30% of the Attribute Leaders chose not to participate.

Organization c) Enables Engineering Motivation / Simplifies Management Metrics:

The fundamental issue involved in developing an Attribute mindset is rationalizing the contributing parameters of hardware that impact attribute performance. For example, identifying the systematic contributions and complex interactions of hardware (Body design, Powertrain Design, Chassis Design) that will deliver a Noise Vibration Harshness attribute target. The Attribute Leaders have the challenge to understand both the customer wants/needs (from a target perspective) and the collective contribution of 10,000 components to evaluate the impact of design decisions / compromises on attributes. They are acting as the systems engineers for specific attributes. But unlike Xerox, Ford does not have a legacy of systems engineers to draw upon. The broader change occurring at Ford is the shift from a hardware / component optimization mindset to a systems engineering requirements-driven mindset. Tools that have helped with this change include QFD, QOS, Taguchi Methods, Experimental Design, and Robustness (to name a few). But this change continues at a glacial pace and requires fundamental changes in the performance metrics for each individual (VP to Engineer) in the Ford product development community.

As the Mustang Team moves from Attribute Targets to compatibility to developing the hardware which will deliver the targets, the requisite systems engineer or attribute expertise may not exist for all attributes. This is a practical result of the migration from system / component focus to attribute focus. Along the continuum from pure attribute targets to actual hardware design are the Program Module Teams or (PMT).

Program Module Teams:
PMTs are the fundamental decomposition of the vehicle by historic functional activity. They are aligned by a Corporate Product Systems Classification code (CPSC) which is the topology Ford created in 1978 to assign design and release responsibility to specific functional areas (PMT) of the vehicle. This created organizational order and defined boundaries. The PMTs include Body Exterior, Body Interior, Chassis, Powertrain, Climate Control, Electrical / Electronics and their respective subdivisions. Historically, the PMTs delivered the Design & Release of their respective components and were the representatives of their functional organizations while matrixing to specific vehicle programs. This preserved and enhanced functional expertise in logical groups and provided the Vehicle Programs with a consistent knowledge base. The PMTs were led by their respective managers on the Vehicle Teams. The PMTs provide the legacy of hardware knowledge and

experience but at the price of organizational boundaries and historical delineation of responsibilities (the proverbial "chimneys"). The current situation on the 200X Mustang team is one of bifurcation. In the early target setting phase, the Attribute Leaders are the prime missionaries of the 200X Mustang. As the program continues, the PMT teams will then be tasked to deliver the hardware that will meet the targets established by the Attribute Leaders. Organizationally, the Attribute Leaders report to Vehicle Engineering, Design, or the CPE. However, the PMTs report to their respective managers and are tracked by the traditional Cost, Weight, Timing, and Quality metrics. PMTs will now also be tasked to meet the Attribute Targets. This separation between establishing the targets and ownership of the hardware will lead to conflict if not managed by a strong CPE demanding communication and full ownership by all factions. As illustrated in the Team Mustang organization structure (Diagram..............) the Design & Release responsibility is separate from the Attribute responsibility. Only one group has combined the Attribute *and* Design & Release function - the EMC Attribute Team Leader / D&R Electrical. We believe a combined Attribute and PMT responsibility, as a single function reporting to the CPE, is the optimal way to include the hardware expertise with the deeper understanding of customer wants, and will serve as a key enabler for Ford to move to a consumer headset.

Organization d) Creates Common Consumer-Focused Alignment:

Possibly the most difficult aspect of incorporating customer attributes into an existing PMT structure is the optimal alignment of attributes with PMTs. An example of this challenge will frame the complexity. One of the 22 200X Mustang attributes is Noise Vibration Harshness (NVH). NVH groups the sources of Noise or Vibrations with the isolation mechanisms to suppress the impact on the customer. The sub-attributes for NVH include Wind Noise, Powertrain, Road, and System. The Mustang team has identified the target range for the NVH attribute to ensure competitive product in the year 200X. (Refer to FIGURE 6-3the Attribute Targets & Status diagram, NVH category). From a customer perspective, NVH is the perception of noise at the ear in the seating positions, the feeling of vibration through the steering wheel - seats - pedals, and the harshness or "boom" effects when driving over bumps. The challenge for the Mustang Team is to understand and align the NVH target with the appropriate PMTs, keeping in mind that the PMTs deliver the hardware which must meet the targets. The solution seems simple: assign the appropriate amount of the attribute target to the PMT that has the dominant influence on the attribute. (For example, the body structure has the greatest influence on vehicle safety, so the Safety attribute target will be championed by the body structures leader). Unfortunately NVH crosses just about every PMT. The Body Structure PMT certainly has a significant contribution, but the Powertrain, External Design, Chassis, and even Climate Control also have significant impacts on NVH. The engine is a source of certain noise, but suppression of the noise could take the form of overhead cams, balance shafts, engine material/mass, OR dash panel insulators, hood insulators, thicker glass, door insulators, air duct baffles, and many other solutions that cross multiple PMTs (and this is just for one specific noise). This is the fundamental risk of Hardware Decomposition – when attributes cross functional organizational boundaries. Which PMT will deliver the NVH target? Since all of the PMTs contribute to NVH, what is the appropriate assignment or partition of the NVH target to ensure ownership of the target? The 200X Mustang program has taken an innovative first step to address this issue in the form of a PMT to PAT Matrix.

The Attribute-to-PMT Cascade illustration below is a matrix that attempts to assess the impact a specific PMT hardware area contributes to all 22 attributes. The 200X Mustang team performed this exercise through cross-functional meetings with PMT Leaders and other hardware experts. The ratings are subjective evaluations from "–" (No Impact) to "3" (High Impact).

200X Mustang
Attribute to PMT Cascade

Code	Program Module Team (PMT) Area	Powertrain	TASE	NVH	Appearance	Veh.Dynamics	Service	Ergonomics	Fuel Economy	Security	Recyclability	Comfort/Convenience	Craftsmanship	Safety	Package	Customization	Life Cycle
000000	Miscellaneous																
010000	Body System																
0101	Body Structure																
010101	- Underbody	2	3	3	1	1	3	-	2	1	2	2	-	3			
010102	- Body Dash & Cowl	2	1	3	3	1	3	-	2	1	3	2	3	3			
010103	- Roof	2	2	2	3	1	-	-	2	1	2	1	1	3			
010104	- Body Side & Qtr	2	2	2	3	1	2	-	2	1	3	-	3	3			
010105	- Package Tray	2	-	2	-	-	1	-	1	2	3	2	-	3			
010106	- Body Rear End	2	2	2	3	2	3	-	2	1	2	1	3	3			
010107	- Deflector & Shields	2	3	-	-	-	2	-	2	1	3	1	2	3			
0102	Front End																
010201	- Front Structure	2	3	3	3	2	3	-	2	1	2	1	3	3			
010202	- GOR	2	3	1	1	-	2	-	2	1	2	1	3	3			
010203	- Front Fenders	2	2	1	3	-	2	-	2	1	3	-	3	3			
010204	- Deflector & Shields	2	3	-	-	-	2	-	2	1	3	2	2	3			
010205	- Hood & Mounting	2	2	1	3	-	1	-	2	2	3	1	3	3			
0103	Body Closures	2	1	3	3	-	1	2	2	3	2	1	3	3			
0105	Interior Trim	1	-	2	3	-	1	1	-	2	3	2	3	3			
0106	Sound/Heat Control	2	2	3	-	-	1	-	-	1	2	3	1	3			
0107	Sealing	1	1	3	2	-	-	-	1	1	2	1	3	1			
0108	Exterior Trim	1	1	-	3	-	1	-	-	2	2	1	3	3			
0109	Rear View Mirrors	1	2	2	3	-	1	2	-	1	2	3	2	3			
0110	Seats	2		3	3	1	2	2	1	1	3	3	3	3			
0111	Glass, Mechanisms	1		2	3	-	1	-	1	3	2	1	2	3			
0112	Instrument Panel/Console	2		3	3	-	3	3	-	2	3	3	3	3			
0114	Handles/Locks	1	1	2	3	-	-	3	-	3	2	2	3	3			
0116	Wipers	1	1	1	3	-	-	1	-	1	2	2	2	3			
0117	Moonroof/Convertible Top	2	1	1	3	-	2	2	2	2	2	3	2	1			
0119	Bumpers	2	2	-	3	-	3	-	1	1	2	1	3	3			
0120	Occupant Restraints	1		-	1	-	2	2	1	1	2	3	2	3			
	Powertrain																
030000	Engine	3	3	3	1	-	3	-	3	1	2	1	1	3			
070000	Transmission	3	3	3	-	-	3	1	3	1	2	1	1	3			
080000	Clutch System	3	1	2	-	-	3	-	2	1	2	3	-	3			
090000	Exhaust	3	3	3	2	-	3	-	2	1	3	1	-	3			
020000	Frame and Mounting System	3	3	3	1	3	3	-		1	2	1	-	3			
040000	Suspension	2	2	3		3	3	-	1	1			-				
0100	Front Suspension	2	2	3	3	3	3	-	1	1	2	1	-	3			
0200	Rear Suspension	2	2	3		3	3	-	1	1	2	1	-	3			
0300	Shock Absorber	2	2	3	3	3	3	-	1	1	2	1	-	3			
0400	Wheels & Tires	2	2	3	3	3	3	-	3	2	3	3	2	3			
050000	Driveline	3	2	3	-	-	1	-	2	1	2	-	-	3			
060000	Brakes	2	1		-		3	-				1		3			
0300	Front Disc Brakes	2	1	3	-	3	3	-	2	1	3	1	1	3			
0400	Rear Disc Brakes	2	1	3	-	3	3	-	2	1	3	1	1	3			
0500	parking Brake	2	1	1	2	1	1	2	1	1	3	1	2	3			
0600	Brake Actuation	2	1	-	-	3	1	-	1	1	2	1	-	3			
0700	Power Brake	2	1	-	-	3	2	-	1	1	2	1	-	3			
0900	ABS	2	1	1	-	3	2	-	-	1	2	2	-	3			
100000	Fuel System	3		1	2	-	2	-	2	2	3	2	-	3			
110000	Steering	2	1	2	1	3	2	3	2	2	2	2	3	3			
120000	Climate Control	2	2	2	1	-	2	3	1	2	3	3	3	3			
130000	Info. Guage & Warning	1	2	1	1	-	1	3	-	1	2	3	1	3			
140000	Electrical Power Supply	2			2	-	2	-	2	2	3	1	-	3			
150000	Entertainment System	1			1	-	1	3	-	2	2	3	3	2			
160000	Vacuum Distribution	1			-	1	2	-	-	1	2	1	-	2			

Figure 6-6 Mustang Attribute to PMT Cascade

The intent of the matrix is to decompose the attribute contributors by PMT structure and ultimately assign a LEAD PMT area for the attribute. Assignment of lead PMT for a given attribute can be accomplished by isolating the High-Impact "3" PMT areas, or through negotiation in the event of ties. As noted earlier, not all of the Attribute Leaders support this process, and some refused to participate. Undaunted, the CPE of the Mustang Team went a step further with this matrix. With the hardware categories indicated, it is now possible to note the dependent variable values for the respective hardware areas. Cost and weight could be itemized and listed next to the hardware. This is a deliberate attempt to force-fit the historical functional organization metrics with customer attributes. The risks of this strategy and the mixed message communicated to the 200X Mustang team will be explored in the next section.

Chapter Conclusion

As noted in the Chapter 1 introduction we have chosen to evaluate the 200X Mustang organization utilizing three lens perspectives on Organizations. As described by Professor Kochan, each of these perspectives can be considered lenses, which are used to view the organization from different perspectives. The three perspectives are strategic design, political, and cultural.

Strategic Analysis:

The strategic design perspective attempts to understand how the flow of tasks and information is designed, how individuals are assigned to roles / responsibilities, how these roles are related, and how the organization can be optimized to achieve its goals. [Multiple Perspectives on Organizational Process, Managing for the Future –

Organizational Behavior & Processes; Ancona et. al.) From the strategic design perspective, the interesting characteristics of the 200X Mustang team include:

- Team Mustang is organized in the Ford version of a program / functional matrix. The program is led by a Chief Program Engineer with the supporting cast representing the functional areas of the company (Body Engineering, Powertrain, Chassis, Visteon components, Climate Control, Electrical, Styling / Design, Manufacturing). The CPE acts as medium-weight program manager and has control of the budget for the program (design, prototypes, expenses, overtime), but does not select the staff, who are allocated by the matrixed department. The unique elements of the matrix organization include new positions of Attribute Leaders, with an emphasis on full staffing of the Attribute Leader role before that of Design / Hardware. Another unique element is the creation of new attributes, beyond the Ford template of 15, to enhance the Mustang's unique characteristics.

- The Attribute Leaders report to both the Hardware Design Managers and the CPE. This allows the CPE to assist and provide credible support to the Attribute Leaders as they work with the Design Managers to create hardware, which will meet consumer expectations in Balanced Business Framework.

- The CPE has dual responsibility for both the Z997 Mustang Program and the current-model Mustang. This is an important link for the CPE to understand the quality / reliability / satisfaction levels with the current Mustang and build from this base. This dual responsibility partially flows to some of the managers reporting to the CPE.

- Once senior leadership approves the budget, the CPE owns and implements the budget for the Mustang Z997 program, which establishes authority and credibility.

(The Company entrusts the CPE with Millions of Dollars). As the fiscal controller, the CPE is the ultimate arbiter of disputes and in this specific sense is acting as a Systems Architect.

- As a co-located, dedicated team, the matrixed team members have the opportunity to obtain maximum information and coordination to the extent allowed by the CPE. Budget reviews, feasibility assessments, package development, styling reviews, and automated control mechanisms are a normal part of the job function. This is desirable since the CPE can foster an open, collaborative environment.

The performance and reward mechanisms of the 200X Mustang Program are a study of inconsistencies. The inconsistencies are endemic to Ford Motor Company as an organization. On the surface, the company has formally expressed its desire to move to a consumer-focused, but shareholder-conscious, corporation. Senior leadership has implemented new reward mechanisms tied directly to Quality, Profitability, and Customer Satisfaction, in an attempt to drive the change. Ironically, the legacy metrics of cost, weight, and time are fundamental factors in determining profitability. So the message to the employees appears to be: Quality is important, Customer Satisfaction is important, but cost, weight, and time are equally important. An unfortunate message occurs when the Company invokes punishment on Senior Leaders for not meeting profitability (e.g., cost, weight, time) in the form of early retirements. The 1986 Taurus, the1989 Thunderbird, and the 1995 Continental are examples where the CPE was asked to retire early for, among other reasons, poor profitability. These actions place profitability ahead of Quality and Customer Satisfaction. The 200X Mustang team is impacted by this legacy. In two of the four key documents described earlier, cost and weight appear on the document along with the Attributes.

Cultural Analysis:

The cultural perspective investigates the influence of values, languages, beliefs, founding legends, myths, and social norms on the organization. One of the keys to the cultural perspective is the unspoken or hidden meaning of symbols.

Like many other international companies born of the later industrial revolution Ford Motor Company has a rich legacy full of history, folklore, and events. Today, the Ford family retains voting interest, but the company has transformed from a tightly controlled autocracy to an international corporation beholden to shareholders. The symbols and practices have also changed over this period. Some of the interesting symbols, conventions, and practices include:

- The coffee club. A quintessential beacon for social interaction and underground conversation of events. Within Ford, each division, department, or section has a form of a coffee club, from a small cabinet next to a support pillar on the assembly line to a built-in dining/break area complete with refrigerators, microwave ovens, garbage disposal, beverage dispensers, swap boards, and snack kiosk. The coffee clubs offer a brief escape from a Dilbert-like world of cubicles. At Ford, the money raised by these clubs is funneled back to local charities. The clubs have changed over time and now coexist with the vehicle programs. The Mustang coffee club has its own insignia proudly displayed over the area and a full complement of beverages and snacks. Understanding the impact coffee clubs have on corporate culture and the charitable side effects, the company permits their existence.

- Vehicle Program jackets. A spoil of the launch wars, occasionally a program CPE will pay for a "Launch Jacket" for each member of the launch team. These were medium- weight designer jackets with knitted insignia/emblems specific to the vehicle program – a script "Mustang" with the galloping pony or a knitted "Lincoln" with the ornamental emblem. The jackets were usually given to the salaried and hourly launch team members shortly after arrival at the assembly plant nine months before the Job 1 date. The actual nine months in the assembly plant were filled with 12-hour days and numerous assembly issues (both design- and non-design-related) as the tooling and assembly process were tuned to build the new model. The jackets symbolized the survival in the pressure of a new model launch and the pride of making an impact on the vehicle.

- An interesting conversion of the Ford workforce has taken place over the past 10 years. In the 1980s, Ford employees demonstrated a strong attachment to divisions or parent organizations. Jackets often advertised "Body Engineering," "Chassis Systems," "Saline Component Operations," "Transmission," or "Cleveland Foundry." Noticeably absent was the Ford symbol from these jackets. This was entirely consistent with the divisional chimneys prevalent in the 70s and 80s. Several organizational changes, restructurings, and a few crises throughout the 80s catalyzed the transformation to the launch or program jacket described above. This transformation is somewhat of a confirmation that the attempts by the company to soften the chimney mindset have been successful. An interesting twist to this transformation is the recent intention to restrict the Ford blue oval trademark to Ford Brand vehicles and remove the trademark from office buildings.
- The use of co-located, dedicated program teams has established an interesting meadow for a program team's culture to flourish. Possessing legitimate budget power, the CPE is in an ideal position to shape the internal culture of the team. The significance of this capability is demonstrated through the communication and information sharing that occurs at all levels of the team. The authors have been on

several teams and personally witnessed the success and failure of CPE's due in part to the ability to build a cohesive, high-performing team.

Political Analysis:

The political perspective investigates the impact of goals, interests, power, and negotiations; it focuses primarily on negotiations as the commingling of these areas to resolve differences in interests between parties through compromise and tradeoffs, to arrive at a solution where all parties are better off with than without the agreement.

The 200X Mustang is 1 year into its product development life – hardly long enough to create controversy or disputes. The team is in the forming stages. But the novelty of the approach by the CPE and the unique features of the organizational matrix have created some political concerns. Those include:

- The CPE, by virtue of the budget, has formal legitimate power for the program. It is the CPE's responsibility to manage the program and deliver the attributes, within the cost, weight, and time indicated by the business structure. Since the CPE has few direct reports, he is frequently required to negotiate with Senior Management for budget money, and with his functional chiefs for headcount resources. In essence, the CPE constructs the boxes in the 200X Mustang Organizational chart and requests people to fill the boxes from the functional / program management chiefs. Once given a budget, the CPE controls the major spending for the program including facilities, tooling, prototypes, and overtime.

- The Mustang team is just entering a challenging point in the program – Attempting to negotiate with the PMT managers to accept the attribute targets and to deliver the hardware. A major piece of this phase will be to include all the stakeholders (Functional activities and Suppliers) in the decomposition / alignment process to provide ownership of the attributes. The goal is to ensure all the attributes have design / hardware owners (PMT teams), and that the PMT teams work cooperatively to develop a harmonized vehicle.

Mustang team members interaction with the CPE is critical to establish credibility and open communication. The Mustang CPE takes his role as mediator / statesman seriously. Many team leader meetings as well as full team offsites with the CPE help to foster open dialogue and build a high-energy team. The CPE's demonstrated interest in the Mustang Clubs, Specialty Equipment Manufacturers, and open communication regarding severe budget shortfalls all combine to create an open environment.

Pugh Score:

The following is the resulting Pugh rating for the Mustang team analysis. Because the 200x Mustang program is in the early stages of product development, changes may occur in the scoring as the processes and organization evolves.

Comparison Pugh

Improvement Measures	Current Tradition.	Mustang Applic.
PRODUCT- World's Leader in Consumer Satisfaction		
a) Decomposition ~~preserves~~ promotes holistic emotional essence	baseline	+
PROCESS Streamlines the Application of System Engineering		
a) Promotes Unified Architectural Vision	baseline	+
b) Improves Method for Optimizing Consumer Attribute Tradeoffs	baseline	+
c) Stronger Emphasis on Consumer Focused Tools	baseline	0
d) Simplifies Consumer Driven Specification / Knowledgebasing	baseline	+
e) Ties Program Team Directly to the Consumer	baseline	+
ORGANIZATION - Natural Consumer Alignment		
a) Establishes Experience	baseline	+
b) Enables Engineering Efficiency	baseline	0
c) Enables Engineering Motivation / Simplifies Management Metrics	baseline	+
d) Creates Common Consumer Focused Alignment	baseline	0
FEASIBILITY OF ADAPTATION		
STATEGIC FEASIBILITY	✓	✓
POLITICAL FEASIBILITY	✓	✓
CULTURAL FEASIBILITY	✓	✓

Figure 6-7 Mustang Application Pugh Score

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"Voice of the Customer Now Demands More From Design Engineers." Managing Design Engineering, June 1999, p. 5.

Ward, Allen, et al. "The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster." Sloan Management Review, (Spring 1995), pp. 43-61.

FORD INTERVIEWS

Bedi, Gurminder Vice President TVC	03/31/99	
Berry, Paul Sen. Tech. Spec. - Sys. Engrg., P/T org.	1/29/99	- 3 Pieces- Attr. Cascade, Less. Learned, Rob. Studies - Need Design Review process with Targets focus - Contact of Art Hyde - CPE Mustang, doing attr. - Ref: 1) Vehicle Targets Process - R. Parry-Jones 2) Sys. Eng. & Proj. Mgt. Synergistic R&R's 3) Proj. Mgt. & Sys. Eng. Where Professions Intersect Generate Synergy not Conflict
Boerger, David H. Director - RVT/Core/QC Quality direction	2/02/99	- Strong agreement with consumer to product translation - Viewed as good, feasible, synergistic with Ford - Ref: 1) Marketing-PD Alignment (Bain & Co.) Rewey/Parry-Jones Paper
Edge, Ernie Tech. Sp. - Sys. Engrg. RVT	2/19/99	- Shared experience, expertise, and support - Offered to arrange meeting with Mazda - Ref: 1) Requirement Cascade Representation 2) Implementation of System Engineering
Himes, Bob Chief Engr. - Attr. Engrg., RVT	1/15/99	- Shared view of issues with System Engrg at Ford - Acknowledged two camps: Attribute vs. Part - Linked Process / Organizational linked approach
Hyde, Art S. CPE - Mustang LVC	3/03/99	- Been working on very similar attribute alignment approach - Offered assistance & program as potential piloting ground - Ref: 1) Japan Product Development Business Practice Study 2) Sys. Engrg. /GAP Platform & Team Structure
Kapur, Dee VLD - F-Series/Expedition	11/18/98	- Interested in Organizational / Process Concept - Provided contact suggestions

TVC	2/04/99	- Stresses creative / entrepreneurial solutions to link with consumer (Michael Dell). - Type of leadership and how to promote mindset
Krafcik, John F. CPE - U222/228/P221 TVC	2/19/99	- Discussed alignment with R. P. Jones' Brand Mgt. - Offered assistance & program as potential piloting ground
Ledford, Mike Exec. Director, Quality	10/22/98 10/29/98	- Shared view for stronger customer link - Detail on areas Ford needs improvement
Matulka, Robert R. Director - Prod. Development, Process Leadership	1/26/99	- Identified need to make process robust to noises - Supports the consumer-driven approach - Advised to consider whole enterprise - Ford/FSS - Willing to advise content and bring into PDLG
McClure, James P. Chief Process Engineer FPDS	1/26/99	(part of Matulka meeting) - Agreed with need to include cultural implications
Zevalkink, Mike VLD, CV/GM/Cont./T/S LVC	3/17/99	- Shared thoughts on consumer group approach - Motivation and passion versus workload smoothing - Japanese auto maker's cultural differences - Attribute focused reorganization not seen as obstacle

MIT INTERVIEWS

Whitney, Dan MIT - Professor	3/19/99	- Very interesting topic - Keeps Attributes alive throughout process to supplement System Engineering shortfalls - Suggest mock-game approach to getting data
Yassine, Ali MIT - Research Scientist	3/19/99	
Eppinger, Steve MIT Assoc. Prof.	TBD	- Ref: 1) Managing the Integration Problem in Concurrent Engineering.

XEROX INTERVIEWS

Shelly Hayes Xerox		- Xerox Interviews
John Elter		- Xerox Case Data