Transformational Metrics for Product Development

By

DAWN M. ROBISON

B.S. in Mechanical Engineering

The University of Michigan, 1989

Submitted to the System Design and Management Program

In Partial Fulfillment of the Requirements for the Degree of

MASTER of SCIENCE in ENGINEERING AND MANAGEMENT

AT THE

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ABSTRACT

The research provides a case study of performance metrics within the framework of the product development process and team effectiveness. A comparative analysis of eight product development teams was done to evaluate the teams' effectiveness in achieving three outcomes – customer satisfaction, shareholder value and time to market. A survey was conducted to evaluate areas where no formal documentation existed and to supplement the existing historical data that were collected from databases and documents. The analysis was done on two levels – by program team and individual respondent – and looked at the level of performance and effort that influenced the specific outcomes.

It was concluded that performance metrics are used within an organization to drive actions, to assess progress and to make decisions. Conclusions were consistent with the premise that people perform to how they are measured and that the team effectiveness can be driven by a set of performance metrics that are aligned with the strategic goal of the organization. Transformational metrics were developed within the framework of understanding the interdependence of the social and technical systems.

Choosing the right metrics is critical to an organization's success because the metrics directly influence behavior and establish the culture within the firm. It was determined that if the right combinations of metrics are selected, teams will act in such a way as to maximize their effectiveness and behave in a manner that achieves the corporate goals.

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Table of Contents

List of Figures

List of Tables

Abbreviations

APQP	Advanced Product Quality Planning
ABS	Affordable Business Structure
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CBG	Consumer Business Group
C/O	Carry Over
CPU	Cost Per Unit
DFMEA	Design FMEA
DVP&R	Design Verification Plan and Report
ESTA	Early Sourcing Target Agreement
FMEA	Failure Mode Effects Analysis
FPDS	Ford Product Development System
HPS	High Priority Supplier
MIS	Months-in-Service
PALS	Program Attribute Leadership Strategy
PIR	Program Implementation Review
PPL	Program Parts List
PSW	Parts Submission Warrant
PFMEA	Process FMEA
QOS	Quality Operating System
R&D	Research and Development
RMS	Resource Management System
R/1000	Repairs per Thousand
SOW	Statement of Work
SVA	Shareholder Value Added
TA	Target Agreement
TGW	Things Gone Wrong
WCP	World Class Process
YIS	Years-in-Service

1 Introduction

1.1 Why Metrics?

Performance metrics are used within an organization for many purposes – to drive actions, to assess progress and to make decisions. Choosing the right metrics is critical to an organization's success because they directly influence behavior and establish the culture within the firm.

Prior work by Hauser and Katz (1998) discusses how individuals perform to the metrics by which they are measured. "Metrics: You are what you measure!" describes the link between metrics and individual as well as organizational behavior:

> ...The link is simple. If a firm measures a, b, and c, but not x, y, and z, then managers begin to pay more attention to a, b, and c. Soon those managers who do well on a, b, and c are promoted or are given more responsibilities. Increased pay and bonuses follow. Recognizing these rewards, managers start asking their employees to make decisions and take actions that improve the metrics. Soon the entire organization is focused on ways to improve the metrics. The firm gains core strengths in producing a, b, and c. *The firm becomes what it measures...*[1]

There are several assumptions contained within this excerpt. One is that there is no single performance metric that can drive behavior in such a way as to adequately achieve the desired outcome. Kerr in 1975 described this phenomenon in the article "On the Folly of Rewarding A While Hoping for B". Therefore, to best drive behavior toward the desired outcome, several metrics must be utilized. Another assumption is that rewards are linked to performance. Performance is measured by metrics. Typically, organizations link incentives to performance. Because individuals strive to maximize rewards, they therefore focus on achieving performance to metrics. Finally, it is believed that metrics influence the organization's core strengths in producing what it measures. The organization can utilize metrics strategically to transform the way it does business.

[1] Hauser, John R., and Gerry Katz (1998), "You are What You Measure!", *European Management Journal*, Vol. 16 No. 5, pp 516-528.

1.2 Thesis Framework and Background

1.2.1 People, Product, Process

Organizations can only achieve success when there is correct alignment of people, product and process as shown in Figure 1.1. A firm may have a brilliant product concept, but without the correct mix of skilled people and an aligned process, the value of that product may never be realized. Similarly, the firm may have an efficient process and people with the right skill set to deliver the product, but without a product that customer will buy, the firm will not be successful in the market place. If any one of these areas – people, product or process – is not aligned, there will be an economic loss for the firm. Therefore, an organization must be able to assess where it stands relative to each of these dimensions and move rapidly toward this alignment to maximize its value and effectiveness.

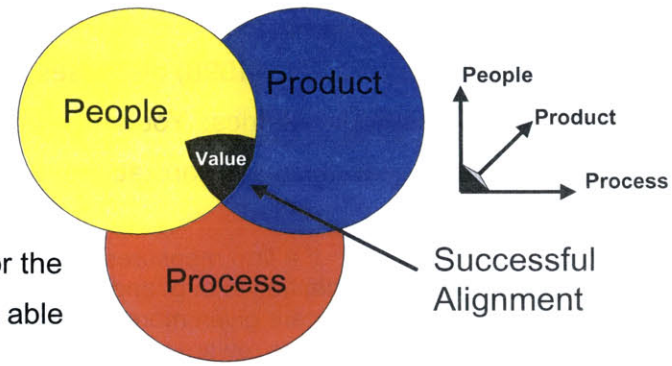

Figure 1.1 Organizational Alignment

This objective of aligning people, product and process by itself is difficult. To compound matters, the environment in which the organization functions is continually changing. Organizations must evolve and adapt in order to remain competitive in the changing environment. A life cycle analysis of organizational responsiveness might be used to describe the process of organizational adaptation to the changing environment (Figure 1.2). As an industry matures, initially the organization is concentrated on R&D

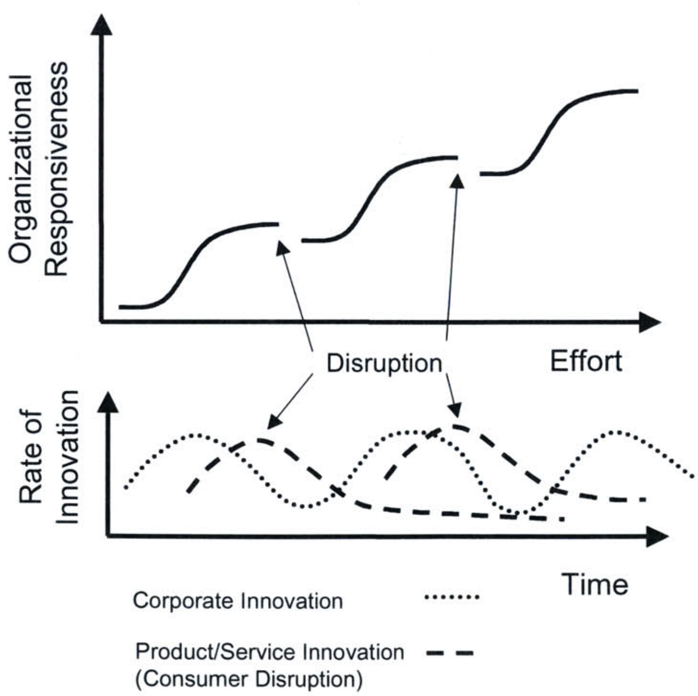

Figure 1.2 Organizational Responsiveness

and engineering. The emphasis is on defining the product and servicing the latent customer need. Typically, there is little or no competition. During the growth phase, the organization focuses on managing the rapid product and market growth and focuses on product quality. Competition increases as new entrants enter the market. When the industry matures, the focus of the organization is on process innovation and cost reduction. Finally, as the industry declines the organizational focus turns to becoming a low-cost producer and/or a niche player. High-cost, low-share competitors fail or are acquired. To gain competitive advantage, companies must evolve faster than the competition. With each of these cycles, the organization must undergo a transformation. Each transformation is motivated by an environmental need (disruption). Process innovation tends to drive organizational transformation. Strategically this notion can be applied to anticipate and to drive process change through re-organization. One way to aid in the organizational evolution is to develop flexible, value-added methods that drive the organization toward its strategic goals.

Transformational metrics are the optimal combination of performance metrics are those metrics that are highly correlated with the desired outcomes of the firm and those metrics that can be used to communicate and drive behavior. Metrics can be strategically utilized to move the organization toward proper alignment and to achieve successful outcomes. Transformational metrics can be developed within the framework of understanding the interdependence of the social and technical systems that exist in the firm.

1.2.2 Social and Technical Systems

For a company to achieve its desired outcomes, its social and technical systems must work together as shown in Figure 1.3. Much emphasis has been placed on improving the performance of the technical system that includes methods & processes, equipment & new technology and materials & supply chain with little focus on the

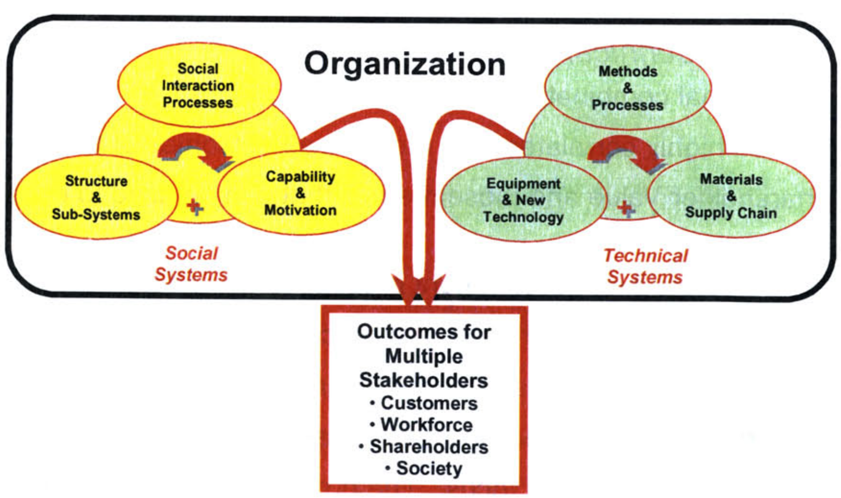

Figure 1.3 Social and Technical Systems Delivering Value to Multiple Stakeholders

dynamic interaction of the social systems. The social system includes the social interaction process, capability & motivation and structure & subsystems of the workforce. Without high performance and alignment of these social systems and technical systems, the company will not deliver value to its multiple stakeholders.

1.2.2.1 Organizational Evolution Model

The organizational evolution model can be used to analyze the impact of technical and social factors on the product development process. The model shown in Figure 1.4 represents this organizational evolution of an industry. There are five organizational phases in this model – creation, growth, functional, coordination and value-driven. Four of the five organizational phases correspond to the life cycle model. The fifth is presented as a bridge to the divide between industry's S-curves. The last three phases will discuss the technical and social frameworks in the context of the product development process.

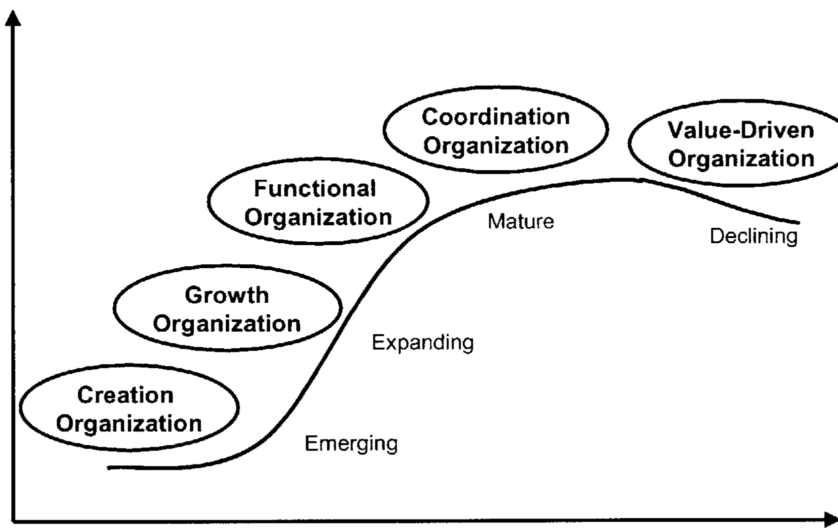

Figure 1.4 Industry S-Curve and Organizational Model

1.2.2.2 Technical Framework

The optimal combination of performance metrics for Product Development are those metrics that are highly correlated with the desired outcomes of Customer Satisfaction and Shareholder Value and those metrics that can be used to communicate and drive behavior.

When the product development process is viewed from an organizational perspective, the characteristics of the product and process evolve over time. The model shown in Figure 1.5 represents this organizational evolution. Its characteristics are analyzed in three phases: the mature industry; the declining phase; and beyond. As the industry matures, the organization has an internal product focus. The product is standardized and profitability relies on leveraging economies of scale. The strategic emphasis of the firm is on the infrastructure and focused on reducing the cost of product development and manufacturing. The result is a standardized product that is unresponsive to the customer's needs and the company is forced to compete on price.

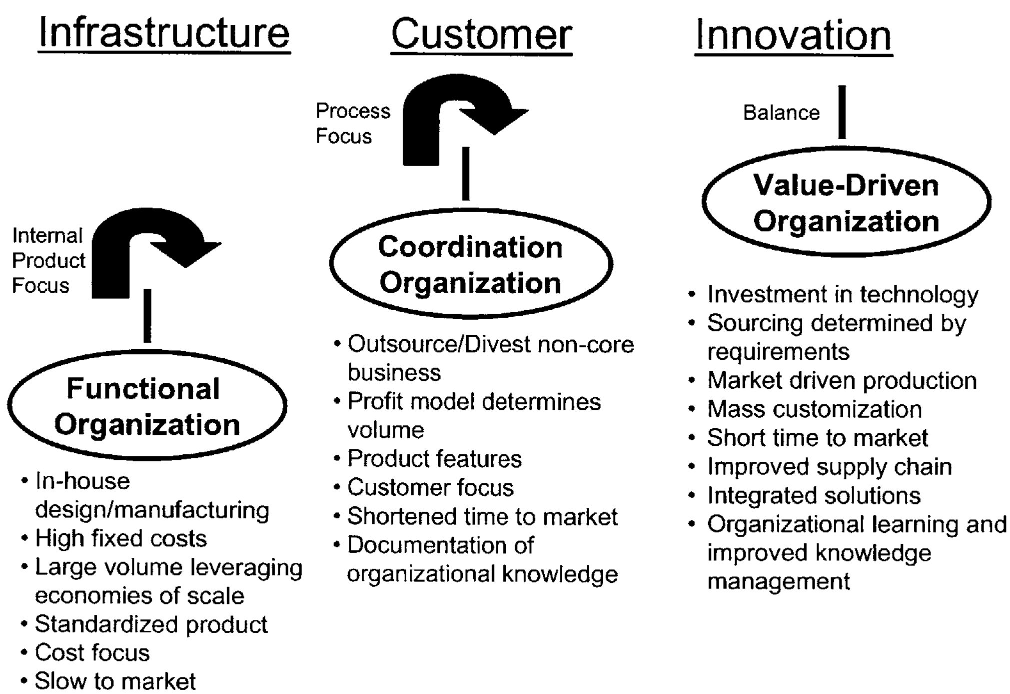

Figure 1.5 Technical Evolution

In the declining phase, the coordination organization emerges. The organization continues to compete on price to strengthen its efforts on being the low-cost producer. Niche players realize greater profits based on customer-perceived value and brand image. In order to improve profit margins, the organization coordinates its efforts through process improvements. It may modify the process to respond to customer needs by emphasizing customer-driven attributes but this strategy may lead to greater product differentiation and lower the effects of economies of scale. Product differentiation increases and the once standardized product becomes more disparate. Process improvements that lead to shorter time to market result in greater profitability by quickly providing the desired product to the customer. The need to reduce lead-time and fixed costs coupled with the desire for product differentiation leads to outsourcing and divesting of the non-core business.

What happens when customers require even more diversity of product and quicker time to market in an industry that appears to be at the final stage of its life cycle? A value-driven organization must emerge. This innovative organization must focus on product and process integration and decision-making that adds value to the customer and the shareholder. It results in a new set of integration skills that make available mass customization and a market-driven product.

1.2.2.3 Social Framework

When the product development process is viewed from an organizational change perspective, the organization's characteristics change over time. These characteristics are defined as social interactions; capabilities and motivation; and structure and subsystems. The model shown in Figure 1.6 represents this organizational evolution.

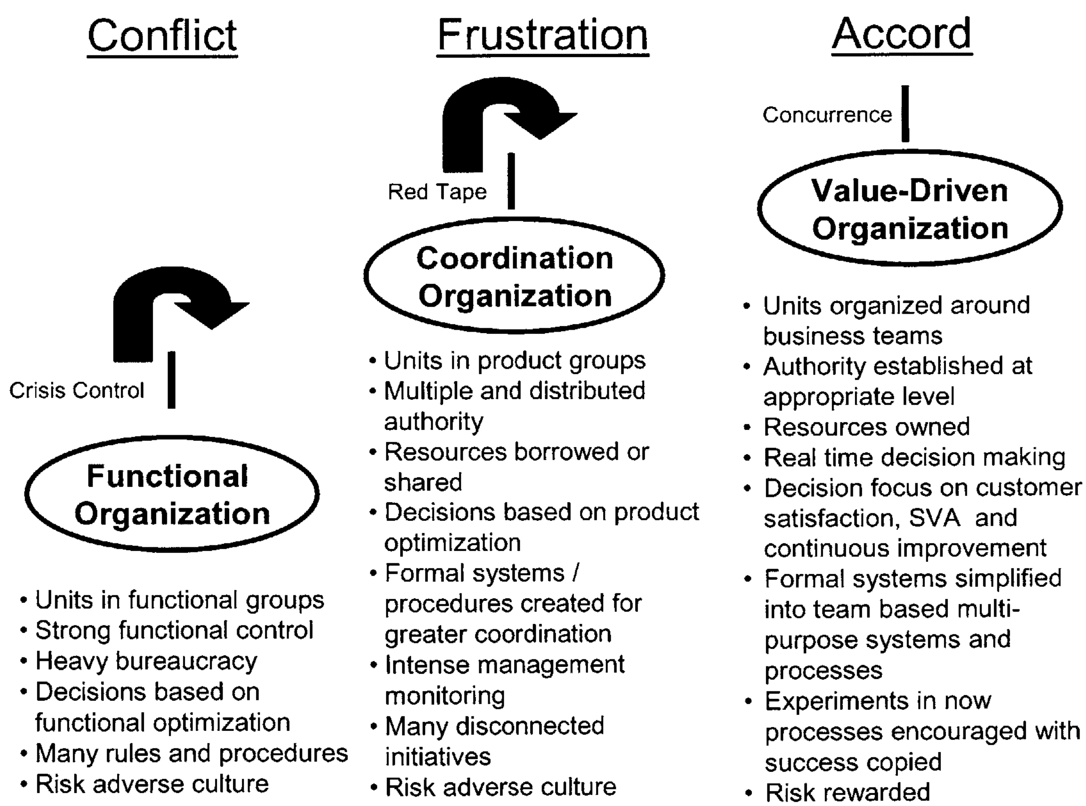

Figure 1.6 Social Evolution

1.2.2.3.1 Social Interaction Process

The social interaction process is defined as the way that problem-solving and decision-making happens within the organization. In the functional organization, the process of problem-solving and decision-making is hierarchical. There is strong functional control. Problems are sent up the chain of command and decisions made by the top-down method. These decisions are typically based on rigid rules and procedures that result in functional optimization. The mode of operation is one of crisis control and the organizational effort is focused on resolving the conflict that is inherent in the functional organization.

In the coordination organization, the process is not as clear. There are multiple and distributed decision makers. The process is based on product optimization and formal systems and procedures are established for greater coordination. There is intense monitoring by management. Decisions and problem-solving are done by consensus. This process is inefficient and can result in non-optimal results and frustration within the organization when individuals are required to focus their effort on overcoming the red tape associated with the coordination organization.

In the value-driven organization, problem-solving and decision-making are made at the lowest level. Decision-making is done real time and is focused on the outcomes. Formal systems are simplified into team based, multi-purpose systems and processes that make problem-solving and decision-making more efficient and effective. There is greater concurrence and alignment of individual and organizational goals. The value driven organization performs with a sense of accord and harmony.

1.2.2.3.2 Capability & Knowledge

Capability and knowledge can be categorized as development of individual and organizational skills and abilities. It can be viewed as how groups develop and those factors that drive the development.

In the functional organization, the capability and motivation are based on functional competence and depth of experience. The knowledge is centrally located in the functional units and the systems and processes are set up to support this functional alignment.

In the coordination organization, the process is not as clear. There is no central location for functional knowledge. Coordination skills are required to adapt to the needs of the product centric organization. Many disconnected, non-replicated initiatives are established when the procedures and systems do not work with the needs of the product team. Functional knowledge dissipates and broad and superficial knowledge of organizational interactions emerges.

In the value-driven organization, knowledge and capability are divided into two categories: functional depth and integration. The value-driven organization is able to develop functional depth that stems from the understanding of the customers and their relation to the product as well as integration capability that provide for quick, efficient assimilation of market and business data that can be translated into product.

1.2.2.3.3 Structure & Sub-Systems

Structure & Sub-Systems can be categorized as the groups, organizations and institution that are formed by the arrangement of the organization. Sub-systems in this structure include the communication channels, information flow, rewards and reinforcement, learning and feedback mechanisms as well as how the organization acquires and retains these elements. Structure and sub-systems involve both formal and informal methods and modes.

Structure can influence the focus of the organization. In a functional organization, there is a strong technology link and a weak market link. This type of organization has strong technical knowledge but lacks coordination of communications and integration with the product as a whole. The project team organization is connected with the market and customer needs but lacks in specific technical knowledge and tends to lead to obsolesce of functional expertise over time. A matrix team can bring together both the functional and the technical expertise of the organization. The matrix organization can lean toward a lightweight team that is focused more on the customer or the heavyweight team that is focused more toward the functional aspects of the business. The matrix structure, however, tends to drive internal conflict within the organization as factions vie over who has the most power and influence over the product outcome. If this conflict can be embraced and viewed as strength and utilized strategically, the organizational growth and knowledge can expand as compared with either the functional or the project team structure.

Assuming that the company's strategy is to be responsive to the customer and retain its core functional capabilities, the matrix organization provides each of these elements. The organization must evaluate and understand the dynamics associated with the changing environment in which the team works as well as the interdependence and duration of the tasks within the project. Allen's work[2] highlights the parameters that must be considered when organizing teams. These parameters include the task/communication interdependence, the project duration and the rates of change of organizational knowledge and market factors[3]. Interdependence vs. rate of change of knowledge suggests that with high interdependence and slower rate of change of knowledge a project team structure is preferred. With low interdependence high rate of change of knowledge, the functional team structure is preferred. A boundary line exists between these regions for a given time to market or duration. If the time line is shifted and the duration becomes larger, the preference is toward functional alignment. Conversely, as the duration becomes shorter, the preference is toward the project team alignment. If the rate of change in the market is considered with the rate of change of knowledge, the faster the market changes the organizational preference is toward the project team; the slower the then market change, functional organization is preferred. Interdependence suggests a preference toward the project team structure, while duration of project suggests the functional team. Teams should, therefore, align toward the structure that fits with the most dominant parameters.

What happens when the project is highly interdependent and at the extremes of market and knowledge change? The question then becomes – How does an organization deal with these hurdles? The organization can try to reduce the interdependence by repartitioning the work or improving the organizational knowledge by cycling people in and out of the functional groups or reducing the cycle time of the project or try to do all three simultaneously. The method that is utilized by the organization will govern how well the team communicates, how it selects and retains workers, learns and retains knowledge and manages the internal conflict inherent in the matrix organization.

1.2.3 3D Model

How can organizations reach the optimal alignment of people, product and process? What "levers" can be operated to guide individuals, to steer the organization and to effectively reach successful outcomes? Success can be achieved by having people in the organization

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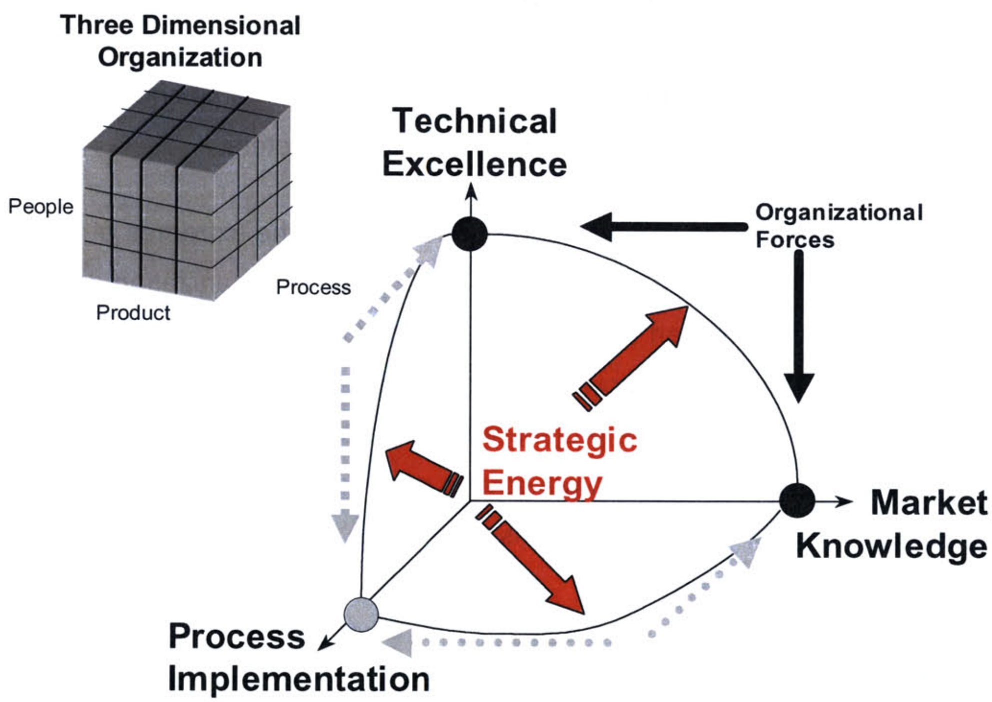
[2] Allen, Thomas J. (1997), "Architecture and communication among product development engineers", MIT Working Paper.

[3] Rate of change of knowledge considers how fast the advancements in technology occur and how much of this knowledge the organization can internalize over time. Rate of change of market considers how quickly the market needs are changing and how the organization can meet this demand over time.

who, with a clear understanding of the market, are able to develop the right technology/ product to fulfill the market needs and to implement a process to successfully create and deliver the product to market.

It is theorized that organizations, which are strong in the three dimensions of technology, process and market, perform better than organizations with lesser performance in any of the three areas. A model reflecting this notion is shown in Figure 1.7. The concept can be applied to program teams within an organization. If a set of performance metrics can be developed to focus the strategic energy of the organization in such a way as to maximize performance on all three of the dimensions, successful outcomes can be achieved.

Figure 1.7 3D Model of Technology, Market and Process



Performance metrics can be strategically utilized to move the organization toward proper alignment of people, product and process by using three high leverage factors to achieve successful outcomes. Transformational metrics can be developed within the framework of understanding the interdependence of the social and technical systems. These performance metrics can be designed to help focus the organization's strategic energy and simultaneously maximize the performance of technology, process and market.

1.2.4 Automotive Case Study

Automobiles represent personal freedom and the ability to travel efficiently over a broad range of locales. The automobile allows individuals wider access to the world around them. Prior to the automobile, primary modes of continental transportation included horses and horse-drawn buggies, as well as boats on rivers, lakes and man-made canals and, finally, trains. One view of the automotive industry is in the framework of efficient mass production where the success could be measured by the performance metric of affordability vs. effort. Another view, as the business transforms to a product and service industry, might be to gauge success on the basis of organizational effectiveness vs. effort. Whatever the measure, historians generally agree that the automobile represents the most important technological revolution of the 20^{th} century. In the rapidly changing market place of the 21^{st} century, it is imperative that the organization be able to adapt and transform while remaining profitable.

The organization of the automotive industry has gone through several changes during the last 100 years, with the greatest changes occurring in the last ten years. In its infancy, the industry was focused primarily on the product (vehicle) and its organization reflected that focus. During the take off period, the primary organization was arranged by function. Now that the industry has reached maturity, the organization has focused its energy on trying to balance its organizational structure in such a way to capture the benefits of the global market place and to attain a clear customer focus, while maintaining its functional expertise. It appears that the industry may be poised on the verge of jumping to a new S-curve. A study of the organizational changes at Ford Motor Company illustrates the automotive industry's evolution.

1.2.4.1 Industry S-Curve

Technologies have provided a means for affordable automobiles that are owned by the masses. Originally, the "technology" used to create a vehicle was hand-assembly. These techniques were soon aided by advances in other technologies such as specialized hand tools and dedicated fixtures. It was not until the assembly line was devised that automobiles were made affordable, thanks to the vision of Henry Ford and his desire to contribute to the advancement of technology and to better society as a whole.

Ford Motor Company sold its first vehicle in 1903 and by 1913, Ford assembly line techniques had begun to carry the automobile into the age of mass production. By 1925, these techniques had evolved and improved to the point that the automobile no longer resembled a horseless carriage but instead the mass-produced all-enclosed steel-bodied vehicles we take for granted today. Process innovation took hold. Standardized manufacturing and assembly processes were developed. Automated machinery was introduced and assembly line innovations aided workers in building cost efficient vehicles. These processes were constantly refined during the 50 years that the industry was in the take-off phase of the technology life cycle. Cost improvements from production techniques were essential to the success or failure of how manufacturers competed in the automotive market. Companies that failed to constantly improve the cost efficiencies of their production techniques gradually fell by the wayside and died as huge economies of scale in the 1950s, 1960s and 1970s came increasingly to define the massive capital investments required not only by individual product programs for the consumer marketplace, but also by demands "external" to the consumer marketplace created by fuel shortages, environmental concerns, government safety regulations and international monetary policies. Cost pressures from all of these sources continue to exert enormous influence on the industry, but in the 1980s and 1990s; the automotive industry realized that the nature of the automotive business must change even more radically in order to stay profitable as it entered what may be considered the mature phase of the life cycle.

Clearly, until the 1980s, the automotive industry was organized around functional areas. These functional areas supported much of the research, design and development of the technologies that were developed, and the organization became focused on the consumer. The structure of the business went from being vertically to horizontally integrated. Much of what was considered in-house business was pushed out to the suppliers. The large, bureaucratic organization that flourished during the growth phase was now too burdensome. A quicker, flexible, customer-driven organization began to emerge. An example of this is Ford Motor Company. It has transformed its organization twice in the last ten years. The first transformation created a matrix organization, which helped it transfer from functional to attribute orientation. The current transformation is heading toward a flat organization that is flexible and focused on vehicle niche markets. These changes to the organization reflected the technologies of in-line sequencing and modularity that have help to improve the cost of design, development and assembly.

Because today's automotive industry has relatively low margins, and despite substantial changes from earlier stages of its development, still retains a significant degree of vertical integration both in design and manufacture. The nature of the automotive business is changing from being a producer of automobiles, to a business with focus on automotive products and services, offering a lifetime of mobility to customers. Recently, there has been a consolidation of many firms. Companies like Ford are buying other automotive manufacturers and partnering with other types of technology companies to strengthen their portfolio. These observable trends beg the question, will the companies that currently comprise the automotive industry survive the move to the next technology cycle and if so, how will the organization transform itself to remain competitive in today's market environment?

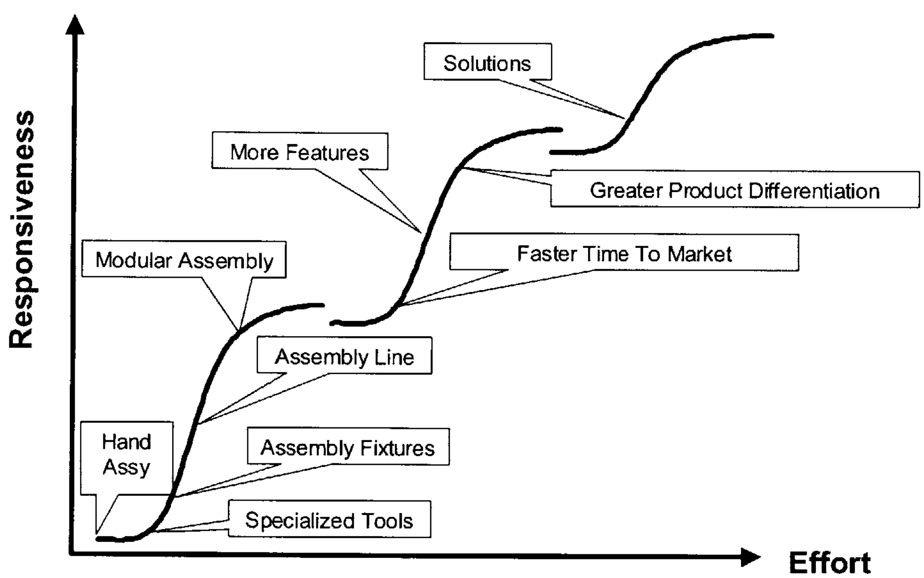


Figure 1.8 S-Curves for the Automotive Industry

When viewed at the macro level, the automotive industry at the beginning of the new millennium appears to be at the mature stage of the lifecycle when using the framework of mass production (affordability). A diagram of the automotive life cycle is shown in Figure 1.8. This "new" automotive industry that provides product and services requires a shift in how the organization performs. The next performance measure of the automotive industry may move the industry to another level. This must be done through vision, strategic planning and leadership.

1.2.4.2 Formal Product Development Organizational Structure

In the early 1990s, Ford Product Development was arranged by functional organization (body, chassis, electrical, etc.) with centralized expertise, economies of scale and deep functional knowledge. There were also staff and functional structures outside of Product Development for Marketing (by division), Manufacturing, Research, Finance, etc. that supported product development. Much of the company's focus was on its domestic market. Because the organizational structure lent itself to infighting and bureaucratic rivalries, and because the individual components of the organization ran with a lack of focused urgency, the company needed to make drastic changes in order to stay competitive in an increasingly demanding marketplace.

In the mid-1990s, the "Ford 2000" reorganization plan was adopted shortly after Chrysler had demonstrated to the industry the of value achieving consumer/product focus and design/development economies through integrated platform teams. Ford reorganized into a matrix formation. Cross-functional teams were formed and carried a heavyweight structure with the vehicle line (product) being in the strong position and with the functions in the weak. All individuals were physically co-located. Ford also changed to a Global Market focus, emphasizing the need for understanding global economics and worldwide consumer buying habits.

Basic research was kept separate from this reorganization or, in other words, kept centralized. However, realizing the benefit of usable innovation, a new organization was formed to handle advanced engineering or applied research. By having centralized research, the company thought that it could keep its competitive advantage and the company believed the advanced research area that focused on applied research would meet the consumers/product line needs.

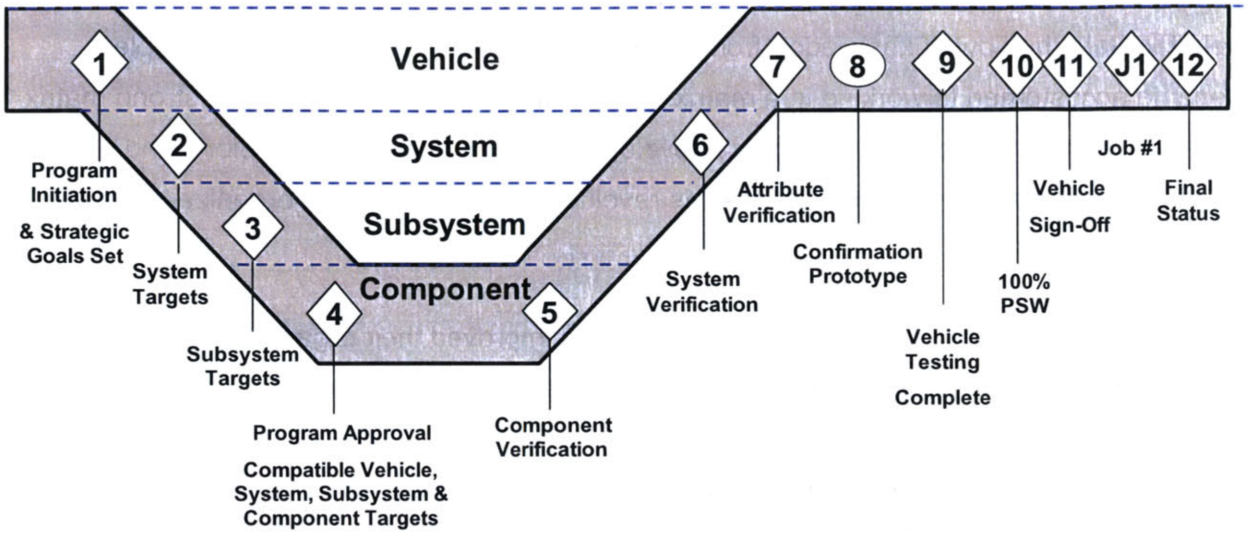
Ford struggled under this organizational structure. People had difficulty with understanding roles and responsibilities, the co-located workplace and, over time, where to go for "expert" advice. For a while, the networks that were established during the time individuals were functionally organized allowed for transfer of knowledge. But, these informal networks quickly eroded. Interventions such as the corporate knowledge base were established to help facilitate the flow of knowledge from function to function. Over the years, people became accustomed to working in a matrix. Co-location became natural. The strong matrix organization allowed for shorter product development time, lower level decisions and a closer tie to the market/consumer, but despite this revolutionary change to the organization, it was still not enough.

As the year 2000 approached and other companies improved their organizations, an even greater emphasis was placed on having a visceral tie to the customers and reducing not only the product development time but also the time from order to delivery and developing core functional expertise. In the current rapidly changing environment, the existing matrix organization was not nimble or flexible enough to lead in the marketplace. Ford now implemented a front to back organization reestablishing regional consumer groups and a strong functional left-hand side to the matrix organization and further compressed the number of salary grade, management and reporting levels. This reorganization eliminated four levels of hierarchy within the organization. In line with this lean approach, Consumer Business Groups (CBGs) were developed. CBGs are organized in a strong matrix formation and add the staff or divisional organizations, including Product Development, Manufacturing, Purchasing and Sales to the decision-making entity. These CBGs operate as individual entities or mini-corporations, with their own profit and loss responsibility and deliverables for customer satisfaction, time to market, etc. Also, these CBGs have added freedom for partnering with outside companies to expand and grow the business.

1.2.4.3 Product Development Process

The Product Development Process is the way the organization designs, develops and verifies the product. Specifically, this process is called the Ford Product Development System and is based on the Systems Engineering "V" Model. The Systems Engineering "V" is a model that describes the various steps and checkpoints in the Product Development Process. Ford's engineering process begins when teams identify the customer driven requirements, corporate strategic goals and government regulations. These well-defined assumptions initiate the vehicle program. A representation of the Systems Engineering "V" Model is shown in Figure 1.9 with the various milestones that are used as checkpoints in the process to assess the team's progress.

Figure 1.9 Systems Engineering "V"



The Ford Product Development Process is the engineering and management process by which a team transforms the voice of the customer into a feasible and verified product of specific cost, quality, configuration and capability. The Product Development Process consists of four phases – define, design, verify and manage. After the assumptions are defined, the design of the product begins. The left hand side of the "V " translates the assumptions into product engineering targets and requirements by an iterative process moving from vehicle assumptions and targets to compatible system, subsystem and component targets. Once all of the targets are defined and compatible within the Affordable Business Structure (ABS)[4], the program is approved and the design and validation of the vehicle and its components proceeds. The right hand side of the "V" represents the serial confirmation process that verifies each level from the lowest level component through the complete vehicle. Once all of the elements of the product are verified, product validation begins. Product validation includes the testing and certification of parts before production Job #1. Prior to production, all of the parts are validated through a Parts Submission Warrant (PSW) and the vehicle is signed off for production. After the vehicle is launched and in production, a summary report of the program is provided to document the Lessons Learned by the program team and recommend future product actions and ongoing requirements in managing the vehicle through the remainder of the lifecycle. Throughout this process, the

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[4] Affordable Business Structure (ABS) Profitability measured as return on sales vs. program objectives.

team uses performance metrics to assess and report progress in achieving the programs strategic goals at various point during the Product Development Process.

Ford Motor Company has a very strong culture that was established by Henry Ford and later influenced by the Whiz Kids, the financial team that led Ford for many years. The company is steeped in tradition and much of its success is attributable to the significant influence that these early leaders had in establishing the methods and metrics the company still uses today. The traditional performance metrics were predominantly financial based. As the industry grew, cost efficiency and economies of scale dominated the decisions of Product Development. With the evolution brought about by Ford 2000, the reengineering of the Product Development Process brought to bear many new process-based metrics. Now, due to the rapidly changing market environment, a new set of innovative value driven metrics are being identified and developed. Over time, these progressions have added to the existing metrics that programs are being asked to use. These legacy systems have many of the same aspirations in assessing and reporting the team's progress, however, each possess a slightly different format. The result of the development of these various metrics is an overload of the system.

1.2.4.4 Future Product Development Structure

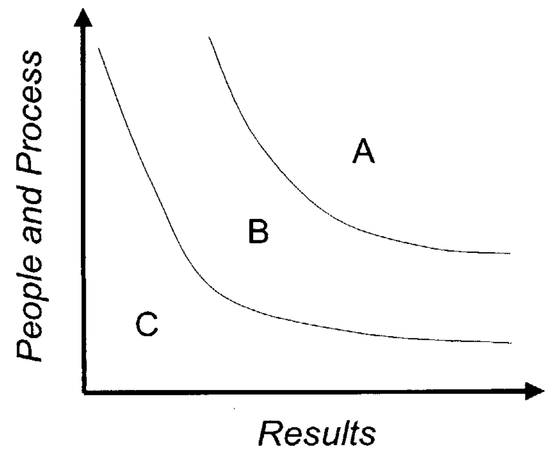
1.2.4.4.1 Need for Organizational Transformation

The goal for the future is to have an even flatter and more flexible organization with greatly reduced organizational rigidity and a process model based upon value and collaboration. Ford's executive plan to achieve these goals calls for significant organizational, incentive and cultural changes. These changes are being strategically planned around an organizational re-alignment of Product Development and Quality, Marketing, Purchasing, Finance, Manufacturing, Business Development, Process Leadership and Human Resources in order to achieve the corporate strategic vision of profitability, product and service excellence, transformation and growth, strong brands, superior customer satisfaction and value, people development, and corporate citizenship.

1.2.4.4.2 Incentives and Performance Metrics

To facilitate the rapid transformation, Ford has recently overhauled its incentive structure. Historically, incentives have been in the form of salary increases and merit bonus. Under this plan, peer groups received similar amounts of bonus. Recently Ford has changed its bonus structure to a pay-for-performance incentive plan. This plan provides no bonus for individuals who do not contribute to the corporate objectives and multiples of bonus incentive for those who contribute significantly. The system is based on an A, B, C rating which evaluates the individual's capabilities in managing people and performance against the outcomes or results (Figure 1.10). At the same time that the pay-for-performance incentive plan has gone into place, the method of evaluation and metrics have changed from being developed on a local basis and linked to the individual to being driven by the corporate goals and linked to the organization. The new metrics set up a tension that drives the organization and individuals toward the goals of profit, customer satisfaction at low mileage, high mileage reliability and shareholder value. In order to be effective the new set of overall governing performance metrics must be cascaded and aligned throughout the various organizations and linked appropriately to incentives.

Figure 1.10 A, B, C Performance Scale



1.2.4.5 Product Development Performance Metrics

To date, much of the corporation's focus has been placed on high-level performance metrics. To ensure the organizational transformation and the achievement of goals, product development performance metrics must be aligned. The product development process has been examined and documented in great detail. However, the sets of transformational performance metrics have yet to be defined. These metrics target key engineering aspects, specifically the areas within product development where the majority of the cost impacts and schedule variances occur. This project intends to establish a systems process approach to evaluate and monitor project status at the systems integration and certification level and to examine the impact of individual pay-for-performance.

2 Objectives and Discussion

2.1 Objective of the Research

This research seeks to discover the combinations of Product Development Performance Metrics that will influence behavior and decision-making within the organization to improve customer satisfaction and maximize shareholder value. Choosing the "right" set of performance metrics is critical to an organization's success. If the optimal sets of metrics are selected, teams will act in such a way as to maximize their effectiveness and behave in a manner that achieves the corporate goals. This thesis will focus primarily on the technical/engineering performance metrics within the product development process and also include recommendations on organizational structure and the impact of incentives.

2.2 Hypotheses

Hypotheses were developed around the areas of product development metrics and individual performance metrics.

2.2.1 Product Development Metrics

- Performance metrics are not aligned.
- Teams are required to use too many metrics.
- Teams do not find value from all of the metrics that they are required to use.
- Teams that used the old metrics performed well when compared to those metrics but did not do as well when compared to value stream metrics. Teams that used value stream metrics performed better than those teams that used only the old metrics. A combination of new and old metrics equates to high customer satisfaction and shareholder value.
- Certain internal performance metrics are more valued by the firm where others have higher value in the market.
- Assembly and Manufacturing reusability has a strong impact on timing.
- As resources increase, time to market increases.
- Teams that have a shorter time to market have higher shareholder value.
- Teams that use analytical methods have products with higher satisfaction.
- Programs that are strong in all three dimensions of technology, process and market perform better than teams with lesser performance in any of the three areas.

2.2.2 Alignment of Individual Performance Metrics and Compensation

- Individual work effort, objectives and compensation are not aligned.
- Teams with greater alignment of objectives, compensation and resultant work effort are more successful with outcomes of customer satisfaction and shareholder value.
- Teams that have higher emphasis on people development and process implementation will have more successful outcomes.
- Teams that have higher work effort in the area of customer satisfaction, performed better on the outcome of customer satisfaction

- Teams that have higher work effort in the area of shareholder value as measured by cost reductions and profitability, performed better on the outcome of shareholder value.
- Individual work effort is driven to a greater extent by compensation when compared to objectives.

2.3 Research Questions

Basic questions addressed in this research are as follows:

- What data are collected for evaluating the effectiveness of the programs?
- What are the factors that contribute to successful programs?
- What are the factors that contribute to unsuccessful programs?
- What are the strengths of the current process?
- What are the weaknesses of the current process?
- What are the optimal combinations of metrics?
- What actions can be implemented to improve the current process?

2.4 Delimitations

This research evaluated the performance of eight vehicle teams by measuring the outcomes of effort vs. effectiveness using a number of quantitative measurements and qualitative interviews. The quantitative measurements were collected from various documents and databases. Although programs used the same basic templates, the documented historical data could not be used in many cases due to the variation in the types of data obtainable or due to the unavailability of these data. Therefore, it was necessary to survey team members to augment the research and compare programs using the same criteria. Individual responses were combined to develop an average team response. The small sample size limits the significance of regressions and calls into question the accuracy of the data. However, this type of analysis can provide insights into relative team performance and behaviors.

3 Research Methodology

This research provides a case study of performance metrics within the framework of the product development process and team effectiveness at Ford Motor Company. To date, much of the corporation's focus has been placed on high-level performance metrics. To ensure organizational transformation and the achievement of goals, product development performance metrics must be aligned at all levels within the organization. The product development process has been examined and documented in great detail; however, a rigorous analysis of the effectiveness of the performance metrics has not been undertaken.

Prior research using an "empirical exploration" of data collected at Ford Motor Company established several key findings: "1) customer satisfaction correlates significantly with the rigor of the product develop process and internal coordination and communication between the core team and the other members of the value chain; 2) time to market shows consistent correlation with profit and profit residuals; and, 3) the calculated weights (leverage and risk discount factor) suggested higher emphasis on capturing manufacturing need and using robust design practices, technology, and differentiation will increase profitability."[5]

This thesis undertakes further research into the way that the social and technical systems interact within Ford's Product Development Process using a combination of quantitative and qualitative approaches.

3.1 Program selection

Eight programs were selected for the project. These programs will be referred to as:

- Program A
- Program B
- Program C
- Program D
- Program E
- Program F
- Program G
- Program H

[5] Majumder, Arpita (2000), "Strategic Metrics for Product Development at Ford Motor Company", System Design and Management Master of Science Thesis, Massachusetts Institute of Technology, Cambridge, MA 02139 (June).

Programs were selected based upon several criteria:

- Vehicle mix consisting of car, truck, SUV and minivan
- Vehicle design and launch origin – Europe and North America
- Various Brands – Ford, Lincoln, Jaguar
- Complexity of product
- Segmentation mix from economy to luxury
- Variation in Customer Satisfaction
- Variation in Shareholder Value Added
- Variation in Time to Market
- Product Development process used
- Job #1 date – 1998MY or later

3.2 Data Collection

This evaluation study involved quantitative historical data analysis and qualitative research gathered from eight product teams, as well as literature review and analysis. The historical documents were collected from specific programs and included program papers, database searches and program specific deliverables and documentation.

3.2.1 Quantitative Research

3.2.1.1 Program Papers

Program Papers are documents created by vehicle teams periodically throughout the Product Development Process. Ford calls these periodic checkpoints milestones. Each milestone requires the program to meet minimum requirements before continuing to the next milestone. The program papers contain assessments of progress toward these defined goals, as well as, discussion of issues facing or faced by the program. At most, milestone reviews, Ford senior management determines whether the program meets the minimum criteria and approves the program to moving to the next milestone. Representatives from various functional areas utilize specific areas of the paper for assessments and decision-making. Data contained in program papers were used as the primary source of the analysis.

3.2.1.2 Functional Deliverables and Documentation

Deliverables and other documentation include all information utilized by management, program teams and functional organizations. These data were collected from functional sources and include metrics data utilized by teams and functional areas to identify and track progress toward deliverables.

3.2.1.3 Warranty Collection Database

The Warranty Collection Database is an internal system that documents worldwide payments of warranty claims. Data are expressed in cost per unit (CPU) and repairs per 1000 vehicles (R/1000). Data collected from this source were limited to three months-in-service (3-MIS) claims and represent same point in time references for each product. These data, which are typical of infant mortality failures, give an indication of design compatibility and launch success. Limitations to this system include data that may be subject to inaccuracy of claims (not true failures), mis-binning of claims (entered into wrong category) and/or incorrect diagnosis (no failure/did not fix root cause problem).

3.2.1.4 Customer Satisfaction Database

The Customer Satisfaction Database is an independent third party market research documentation system that tracks customer product satisfaction ratings for internal products and select competitive products. Data are expressed in percentages of satisfaction and things gone wrong (TGW). Analysis is provided showing trends and comparisons against the competition. Data are available for vehicle lines beginning with customer's satisfaction evaluations at three months-in-service (3-MIS) to ten years in service (10-YIS). Analysis of 3-MIS Customer Satisfaction and TGW data was used as a common reference point for all product comparisons.

3.2.1.5 Lessons Learned Database

Lessons Learned are records containing knowledge obtained from the development or use of a product, process, or technology that, when appropriately applied, will provide for continuous improvement or prevention of concern recurrence. The Lessons Learned Database is a formalized, standardized corporate knowledge management system for capturing information that affects design practices and engineering decisions. Information was used to clarify and elaborate on specific areas of the analysis.

3.2.1.6 Resource Management System

Resource Management System (RMS) is a computerized estimating tool for forecasting Product Development headcount requirements for Product Programs over time. It is currently used as an allocation tool to guide the distribution of Vehicle Center headcount across functions and programs. RMS is used for identifying resource needs based on program scale and complexity. It is broken down into functional areas associated with

Vehicle Center/Program. Program resource data was used as a comparison among programs.

3.2.2 Qualitative Research

3.2.2.1 Individual Evaluation and Belief Survey

A survey was developed to obtain data on individual's evaluation of beliefs about the selected programs. A total of 104 surveys were sent out to individuals who worked in the specific roles on the teams. A total of 60 surveys were returned (about 58%). A description of the specific roles and the number of responses by role are shown in Table 3-1

Table 3.1 Individual Respondents Information

Program Role	Description	# of Resp.
Chief Engineer	Responsible for the program outcomes, processes and organizational structure and staffing	6
Functional Manager	Responsible for the program functional deliverables and staffing in areas that include Vehicle Integration, Body Engineering, Chassis Engineering, Powertrain Engineering, Electrical Engineering and Program Management.	11
Staff Manager	Responsible for the program deliverables and staffing in areas that include Finance, Manufacturing and Assembly, Quality and Timing.	5
Functional Supervisor	Responsible for a subset of the program functional deliverables in areas that include Vehicle Integration, Body Engineering, Chassis Engineering, Powertrain Engineering, Electrical Engineering and Program Management.	17
Staff Supervisor	Responsible for a subset of the program deliverables and staffing in areas that include Finance, Manufacturing and Assembly, Quality and Timing.	4
Engineer	Responsible for the deliverables within the subset of Vehicle Integration, Body Engineering, Chassis Engineering, Powertrain Engineering, Electrical Engineering and Program Management.	9
Process Specialist	Responsible for coaching the program team on processes and the evaluation of those processes.	8

The resultant responses by individual were then aggregated and provided an average team response. Both individual and team aggregate responses were used in the analysis.

Table 3.2 Program Team Responses

Program	# of Responses
A	10
B	8
C	4
D	6
E	8
F	10
G	9
H	5
Total	60

3.2.2.2 Interviews

Interviews were conducted with key individuals to provide clarification about the programs and to fill in gaps in the data. These interviews provided a behind-the-scene perspective about the events and interactions within the programs.

3.2.3 Identification of Variables

3.2.3.1 Outcomes

Three outcomes were analyzed: Customer Satisfaction, Shareholder Value Added (SVA) and Program Timing for each program.

Customer Satisfaction scores are derived from customer survey information. Customer Satisfaction data at 3MIS after Job#1 was used as a common reference point for all product comparisons and is measured on a scale from 0 to 1.

Shareholder Value Added[6] is a measure of how much value program teams contribute. The team's contribution to SVA was normalized and scaled from 0 to 1.

Program Timing is a measurement of how well the team met the planned timing. The program's timing was normalized and scaled from -1 to 1 with 0 showing that the team was successful at meeting the planned timing.

Outcome	Mean	Standard Deviation
Customer Satisfaction	.70	.05
Shareholder Value Added	.03	.08
Program Timing	.14	.56

[6] Shareholder Value = Net Income – (Net Operating Assets X Cost of Capital)

Warranty data of CPU and R/1000 was used to evaluate the team's performance and is treated as an outcome. Analysis of 3-MIS cost and repair data was used as a common reference point for all product comparisons.

3.2.3.2 Overall Product

Overall product describes the type of platform that the program developed. Overall Product is treated as continuous response. The survey scale below shows the various responses that were provided to the respondents and the table below provides the mean and standard deviation of the response.

Survey Scale:

1	Breakthrough Product
2	New Company Platform
3	Derivative of an Existing Platform
4	Primarily C/O with Minimal Updates to Existing Product

Response	Mean	Standard Deviation
Overall Product	2.57	.56

3.2.3.3 Program Duration

Program Duration is a measurement of how individuals believed that the team performed relative to the planned timing given the scale (size) of the program.

Survey Scale:

1	About Average	
2	Longer than Average	By (%)
3	Shorter than Average	By (%)

These measures were combined to give a combined program duration score using a scale of –1 to 1 and treated as a continuous response.

Combined Survey Response	Mean	Standard Deviation
Program Duration	-.09	.22

3.2.3.4 Technology

Technology describes the newness of the technology being incorporated into the program. Program papers provided metric data on the use of new technology. The actual numbers reported by the team on use of new technology ranged from 3 to 8. The mean was 6.5 with a standard deviation of 1.8.

The newness of the technology and the state of development that the technology had prior to being incorporated into the program was evaluated on a four-point scale. This measure is an indicator of how much effort the team put into developing the new technology.

Survey scale:

1	Off the Shelf Technology
2	Proven Technology (requiring minimal changes to implement)
3	Implementation Ready New Technology (requiring low degree of program development)
4	Radically New Technology (requiring high degree of program development)

Survey Response	Mean	Standard Deviation
Technology Impact	2.90	.21

Technology Impact measures how the technology was perceived to have been received by the customer. Technology Impact is measured on a scale from high to low and is treated as a continuous response. The table below provides the range of response to the question in which the respondent was requested to provide the strength of his or her perception to the question that was posed.

Survey Response	High				Low
Technology Impact	1	2	3	4	5
	Mean			Standard Deviation	
	2.57			.67	

3.2.3.5 Market Drivers

Market drivers measures how focused the team was on understanding and meeting the customer's needs and how well the segment is defined. Customer Needs defines how the program approached understanding and meeting the customer's needs. Customer Needs is measured on a spectrum of meeting stated customer need vs. latent customer needs and is treated as a continuous response.

Survey Response	Stated				Latent
Customer Needs	1	2	3	4	5
	Mean			Standard Deviation	
	2.55			.43	

Segmentation measures the type of segment the program was entering. Segmentation can help to understand how well the customer in the segment were defined and how much data the program may have had on the specific market segment.

Survey scale:

1	New Segment
2	Many New Entrants
3	Few New Entrants

Survey Response	Mean	Standard Deviation
Segment	2.62	.15

3.2.3.6 Task and Process Interdependence

Task Interdependence describes the number of inputs required to complete tasks. Task Interdependence is measured on a scale from high to low and is treated as a continuous response.

Survey Response	High				Low
Task Interdependence	1	2	3	4	5
	Mean			Standard Deviation	
	1.83			.40	

Process Interdependence describes the nature of the tasks and the amount of rework required to complete tasks. Process Interdependence is measured on a scale from high to low and is treated as a continuous response.

Survey Response	Highly Iterative				Sequential
Process Interdependence	1	2	3	4	5
	Mean			Standard Deviation	
	2.56			.56	

3.2.3.7 Product and Process Knowledge

Product Knowledge measures the amount of information that was available within the company on the technology and the rate of change of knowledge that the team needed to acquire that was associated with the technology. Product Knowledge is measured on a scale ranging from new to old technology and is treated as a continuous response.

Survey Response	New				Old
Product Knowledge (Type of Technology)	1	2	3	4	5
	Mean			Standard Deviation	
	2.97			.49	

Process Knowledge measures the amount of information that was available within the company on process and the rate of change of knowledge that the team needed to acquire to develop the process. Process Knowledge is measured on a scale ranging from the new process described as the Ford Product Development System to the old process that was called the World Class Process. Process Knowledge is treated as a continuous response.

Survey Response	FPDS				WCP
Process Knowledge (Process Used)	1	2	3	4	5
	Mean			Standard Deviation	
	3.00			1.34	

3.2.3.8 Process Detail

Process Detail measures the availability of process detail and the knowledge that the team had about the process used. Process Detail is treated as continuous response.

Survey scale:

1	Available and proven off-the-shelf documentation Team has tacit knowledge of the process
2	Some available documentation
3	Team required documentation and was able to use it effectively on program Available documentation did not meet needs of program
4	Some process adaptation required by team Radically new process with little documentation
5	Team required to develop process

Survey Response	Mean	Standard Deviation
Process Detail	2.70	.43

3.2.3.9 Resources

Resource Knowledge measures the collective knowledge of the team on a spectrum from deep functional knowledge to broad process knowledge. Resource Knowledge is measured on a scale ranging from 1 to 5 and is treated as a continuous response.

Survey Response	Deep Functional				Broad Process
Resource Knowledge	1	2	3	4	5
	Mean			Standard Deviation	
	2.54			.42	

Resource Timing measures the timing of when the team received the resources and whether or not the resources had the correct skill level. Program resource planning data was collected but no actual data was available and therefore could not be analyzed relative to the data collected from the survey responses. Resource Timing is treated as continuous response.

Survey scale:

1	Received skilled resources on time
2	Received skilled resources after they were needed
3	Received resources without the correct skills on time
4	Received resources without the correct skills after they were needed
5	Did not receive all the resources that were needed

Survey Response	Mean	Standard Deviation
Resource Timing	2.87	.84

3.2.3.10 Organizational Structure

Organizational Structure measures responses on the type of organization that the team structured during the Product Development Process and provides insight into the way it functioned. All teams were co-located. Functional Departments are focused on the system technology and encourage communications along the function relative to technology development and optimization. Attribute groups are more focused on meeting customer needs and are focused on the vehicle and cross system tradeoffs. Business Units are focused on the entire value chain and manage decisions based on the value stream. Organizational Structure is treated as continuous response.

Survey scale:

1	Functional Departments
2	Attribute Groups
3	Business Unit

Survey Response	Mean	Standard Deviation
Organizational Structure	1.36	.13

3.2.3.11 Organizational Focus

Organizational Focus is a set of trade offs between two dimensions and measures the effort of the team on a continuous scale.

Survey scale:

1	100% Functional Excellence
2	75% Functional Excellence / 25% Customer Needs
3	50% Functional Excellence / 50% Customer Needs
4	25% Functional Excellence / 75% Customer Needs
5	100% Customer Needs

Survey Response	Mean	Standard Deviation
Functional Excellence vs. Customer Needs	2.81	.41

Survey scale:

1	100% Functional Excellence
2	75% Functional Excellence / 25% Process Implementation
3	50% Functional Excellence / 50% Process Implementation
4	25% Functional Excellence / 75% Process Implementation
5	100% Process Implementation

Survey Response	Mean	Standard Deviation
Functional Excellence vs. Process Implementation	2.24	.27

Survey scale:

1	100% Customer Needs
2	75% Customer Needs / 25% Process Implementation
3	50% Customer Needs / 50% Process Implementation
4	25% Customer Needs / 75% Process Implementation
5	100% Process Implementation

Survey Response	Mean	Standard Deviation
Customer Needs vs. Process Implementation	2.33	.48

3.2.3.12 Product Development Tools

Measures the response on the level of effort that was focused on the use of Computer Aided Engineering (CAE) and Computer Aided Design (CAD) tools, Robustness Practices that include Failure Mode and Effects Analysis (FMEA), Parameter Design, Design of Experiments as well as Tolerance Design and Reliability Verification. These measures are treated as continuous variables.

Measure	High				Low
CAE/CAD Tools	1	2	3	4	5
Robustness	1	2	3	4	5
Reliability Verification	1	2	3	4	5

Survey Response	Mean	Standard Deviation
CAE/CAD Tools	2.02	.58
Robustness	2.24	.80
Reliability Verification	2.10	.59

3.2.3.13 Performance Metrics

Performance Metrics are measures that a team uses to plan, manage, track and report status to objectives. The performance metrics are classified into seven categories: Quality Operating System (QOS), Ford Product Development System (FPDS), Program Implementation Review (PIR), Program Health Chart, Program Specific, Functional Organization and other types of metrics.

Performance Metric Use measures individual responses on the type of performance metrics used by a product development team on which the person worked. Performance Metric Use is treated as a nominal response.

Survey scale:

1	Yes
0	No

Frequencies:

Performance Metric Use	Yes	No
Quality Operating System Metrics	87%	13%
Ford Product Development System Metrics	50%	50%
Program Implementation Review Metrics	13%	87%
Program Health Chart Metrics	78%	22%
Program Specific Metrics	67%	33%
Functional Organization Metrics (Manuf, Quality, APQP, other)	73%	24%
Other	13%	87%

When a performance metric was identified as used, Performance Metric Value measures individual responses on the worth and merit of the type of performance metrics used by the product development team. Performance Metric Value is treated as a nominal response.

Survey scale:

1	Yes
0	No

Frequencies:

Performance Metric Value	Yes	No
Quality Operating System Metrics	54%	46%
Ford Product Development System Metrics	40%	60%
Program Implementation Review Metrics	50%	50%
Program Health Chart Metrics	45%	55%
Program Specific Metrics	83%	17%
Functional Organization Metrics (Manuf, Quality, APQP, other)	57%	43%
Other	100%	0%

Program Specific Metrics were believed to add the greatest value. By definition, program specific metrics are unique to the program and therefore these metrics could not be analyzed across programs. Similarly, QOS and most Functional Organizational metrics were not consistent among programs. The only sets of metrics that were common and comparable were the Program Health Chart Metrics and a few Functional Organization Metrics.

Alignment of Metrics measures individual responses to beliefs on the how aligned the various types of metrics used by the team were. Alignment of Metrics is treated as a nominal response.

Scale	Response	Frequency
1	Yes	17%
0	No	83%

When asked if all of the metrics that the team was required to use were aligned, 83% responded that they were not aligned

Dissimilar Metrics measures individual responses to beliefs on whether teams are required to use too many dissimilar metrics. Dissimilar Metrics is treated as a nominal and continuous response.

Scale	Response	Frequency
1	Yes	75%
0	No	25%

Three quarters of the respondents stated that the team was required to use too many dissimilar metrics.

3.2.3.13.1 Program Health Chart

There are eighteen metrics associated with the Program Health Chart. These metrics measure the outcomes of Customer Satisfaction, Program Timing, Profitability as well as Functional Performance. Reporting of status to these metrics occur at various milestones in the Product Development Process. Each team was evaluated by averaging the number of elements reported red, yellow and green across five milestones.

Survey scale:

Green	%
Yellow	%
Red	%

Distributions:

Program Health Chart	Mean	Standard Deviation
Green	.67	.13
Yellow	.25	.09
Red	.05	.05

3.2.3.13.2 Functional Organization Metrics[7]

Quality Metrics including Things Gone Wrong (TGW) as well as warranty measures of Cost Per Unit (CPU) and Repairs per thousand (R/1000) were scaled from 0 to 1.

Quality Metrics	Mean	Standard Deviation
TGW	.46	.35
CPU	.73	.36
R/1000	.70	.33

Advanced Product Quality Planning (APQP) is a standardized process and communication method used in product development by OEMs and suppliers. Comparable data for only three elements, Supplier, Design Verification / Production Validation Testing Completed and Part Submission Warrant (PSW), were available for all programs. Partial data on Failure Mode and Effects Analysis (FMEA) data was available. APQP metrics were given a scale from 0 to 1.

APQP Metrics	Mean	Standard Deviation
Supplier	.63	.39
FMEA	***	***
% Design Verification / Production Validation Testing Completed	.92	.13
% PSW	.76	.15

Manufacturing Metrics measure the amount of plant reusability. Plant Reusability was given a scale from 0 to 1.

Manufacturing Metrics	Mean	Standard Deviation
Plant Reusability	.65	.35

[7] All data under Functional Organization Metrics has been disguised for confidentiality.

Program Strategies are developed at the beginning of each program and targets set for percentage of carry over parts, the number of new technology and the product attribute strategy. These measures directly impact the outcomes of Customer Satisfaction, SVA and Time To Market.

Program Strategies	Mean	Standard Deviation
% Carry Over Parts	.54	.23
# of New Technologies	6.5	1.8
Attribute Strategy – Targets Met	.80	.15

One financial measure was used to analyze the program effectiveness at cost management. Cost Management was given a scale from 0 to 1.

Financial Measure	Mean	Standard Deviation
Cost Management	.72	.33

3.2.3.14 Yearly Objectives/Compensation/Work Effort and Alignment

Yearly Objectives, Compensation and Work Effort measure individual responses to the amount of effort spent on a specific category of work given a stated objective and level of compensation. Work Effort is treated as a continuous response while Yearly Objectives and Compensation are treated as continuous and nominal variables. The response scale is from 0%-100%.

Measure of	Objectives	Compensation	Work Effort
People Development	%	%	%
Process Implementation	%	%	%
Cost Reductions	%	%	%
Profitability	%	%	%
Customer Satisfaction	%	%	%
TOTAL	100%	100%	100%

Responses were analyzed in two ways – by looking at the population as a whole and by looking at the subset of the population that consisted of Functional Manager, Staff Manager and Chief Engineer. The subset population had larger bonuses and compensation that directly linked to corporate stated objectives. This subset population will be referred to as Management.

Response for Entire Population on	Objectives		Compensation		Work Effort	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
People Development	0.09	0.08	0.05	0.06	0.09	0.09
Process Implementation	0.24	0.27	0.26	0.33	0.31	0.30
Cost Reductions	0.15	0.17	0.14	0.20	0.11	0.15
Profitability	0.17	0.17	0.22	0.22	0.14	0.17
Customer Satisfaction	0.35	0.24	0.29	0.25	0.35	0.25

Response for Subset of Management on	Objectives		Compensation		Work Effort	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
People Development	0.11	0.09	0.07	0.07	0.12	0.10
Process Implementation	0.20	0.26	0.17	0.27	0.22	0.22
Cost Reductions	0.08	0.09	0.14	0.20	0.11	0.14
Profitability	0.20	0.19	0.30	0.26	0.18	0.18
Customer Satisfaction	0.38	0.22	0.32	0.24	0.36	0.20

Alignment of Yearly Objectives, Compensation and Work Effort measures individual responses to beliefs on the alignment of the three categories. Alignment of Yearly Objectives, Compensation and Work Effort is treated as a nominal response.

Scale	Response	Frequency Entire Population	Frequency Management
1	Yes	43%	44%
0	No	57%	56%

Beliefs about Alignment of Yearly Objectives, Compensation and Work Effort were similar when comparing Management and the entire population.

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4 Data Analysis and Findings

4.1 Program Clusters

Programs were clustered using the responses on aspects of the Product Development Process that influence the main factors of Customer Satisfaction, Time To Market and Shareholder Value. These included the aggregate program responses to how successful the team was in meeting the planned program timing given the scale of the program, how much the team was required to develop the technology that went into the program, how the program approached understanding the customer and the customer's needs, beliefs on the interdependency of tasks, the amount of rework required, how much the team was familiar with the process that was used and how the program was structured. Figure 4.1 shows the results of the clustering.

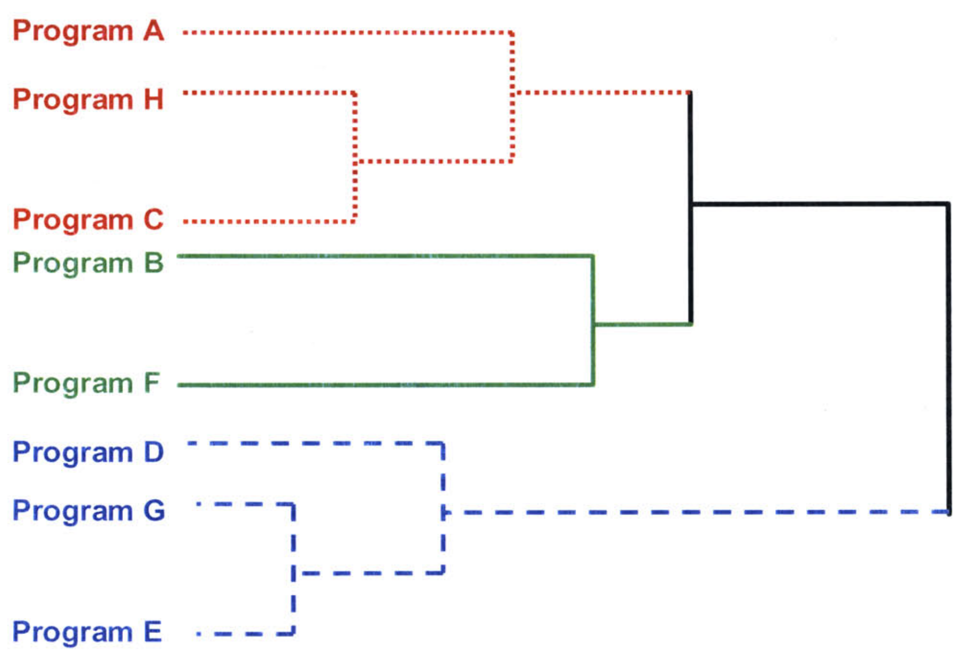

Figure 4.1 Program Clusters

Two aspects of the clustering were notable. The first was that the programs were roughly clustered based on the management and organizational reporting structure. Management and organizational structure appears to be a driving influence on the outcomes and behaviors of teams and is discussed in the later section on the Alignment of Work Effort, Objectives and Compensation. The second notable aspect was that vehicles were clustered on various levels based on the type of market for which the vehicle was designed. There was a clear difference between passenger car and non-passenger car. A split occurred and separated single market vehicles from global vehicles. Also, the clustering was broken down by the region where the vehicle was designed. Due to the proprietary nature of the data, further analysis and discussion of program is not feasible. However, it can be said that the clustering reflected geographic location, program scope and vehicle type with remarkable accuracy.

Programs were then mapped against the internal measures of the Product Development Process. Perceptual maps of the clusters from several two dimensional views are shown below. Each of the regressions shows the distributions of one continuous variable as it relates to another. The resultant scatter plots show that the clusters form groups on each of the dimensions despite the low correlation of the variables. Programs D, E and G had more successful outcomes of Customer Satisfaction and Shareholder Value; Programs A, B, C, F and H had mixed outcomes when measured by the same criteria. Because of the random variation in the measurements, an orthogonal fit[8] was used in place of a standard least squares method. The density ellipses shown represent the 95%[9]. The mappings appear to be directionally correct.

Figure 4.2 Shareholder Value vs. Program Timing

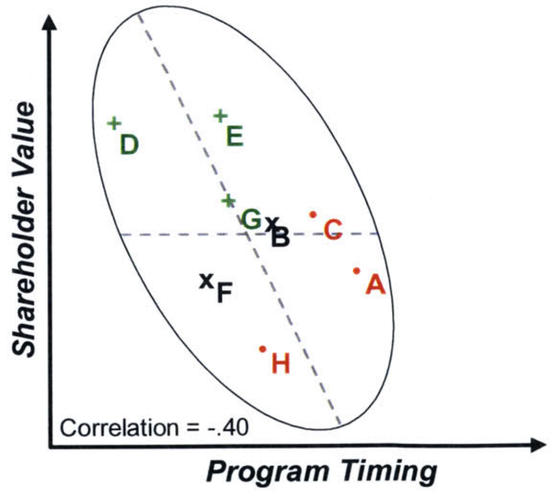

Figure 4.2 relates Shareholder Value to Program Timing. As Program Timing increases, Shareholder Value decreases. This suggests that as teams that delivered the program to market the faster, fewer resources were used. This leads to the hypothesis that as resources including manpower, prototypes and facilities increase, time to market increases. It will be shown later in the analysis that programs that lower the amount of resources used in terms of manpower and increase the

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[8] This method was used to adjust for the variability in X as well as Y. The standard least square method assumes that the X variable is fixed and the Y variable is a function of X, plus error. Because of the random variation in the measurement of X, a line that is perpendicular to the line of fit is a better representation than that of a standard regression line. One advantage to this approach is that the computation provides for the means to predicted values for both Y and X.

[9] Density estimation fits a bivariate distribution to the points.

use of analytical tools and reusability of assembly and manufacturing facilities have a shorter time to market. Programs C has slightly higher Shareholder value when compared to its grouping. It was found that Program C had a significantly higher focus on profitability than any of the other program. The team's focus on profitability and cost reductions resulted in higher Shareholder Value.

Figure 4.3 Customer Satisfaction vs. Program Timing

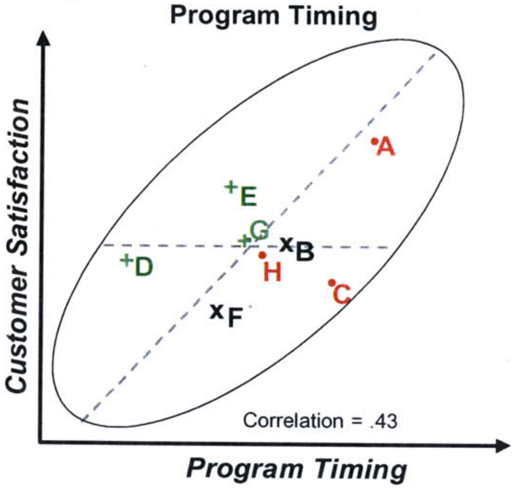


Figure 4.3 relates Customer Satisfaction to Program Timing. As Program Timing increases, Customer Satisfaction increases. This suggests that teams that spend more time during the Product Development Process provide the customer with a more pleasing vehicle. Perhaps when more time is spent on understanding the customer and iterating the product design, a more successful product is produced. Clearly, Program A had the longest product development cycle. This team's mission was to achieve a vehicle that was highly valued in the market place. The program was delayed to ensure that the vehicle attributes met the market requirements. This high Customer Satisfaction focus resulted in a successful outcome at the expense of Shareholder Value and Program Timing. Similarly, Program D spent much of its effort on Customer Satisfaction. Given the relatively shorter product development time, the program could have had lower satisfaction; but, due to the emphasis on meeting their targets, the team was relatively successful.

Figure 4.4 Shareholder Value vs. Customer Satisfaction

Figure 4.4 relates Shareholder Value to Customer Satisfaction. As Customer Satisfaction increases so does Shareholder Value. This suggests that when factors align within the product development process they can have a direct effect on the outcomes of Customer Satisfaction and Shareholder Value. Program emphasis and effort in the areas of

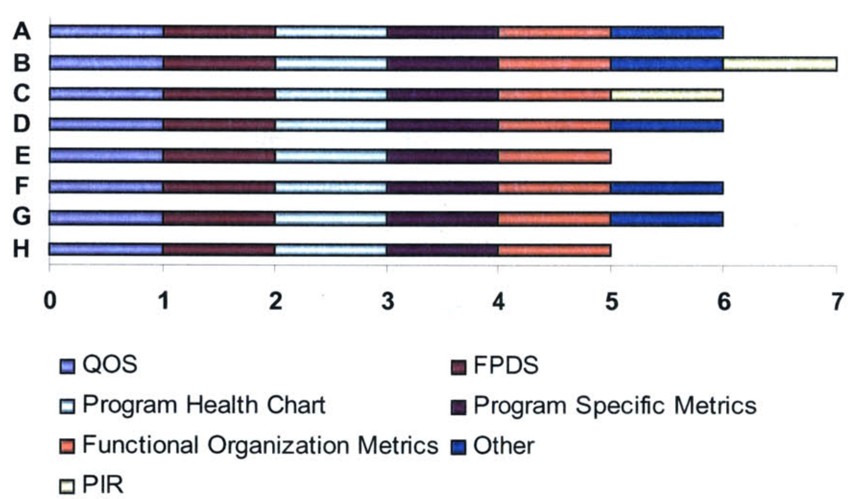
process implementation, market understanding and functional knowledge can affect the outcomes of Customer Satisfaction and Shareholder Value. Understanding of how specific Product Development Metrics effect program outcomes and identifying which of the metrics has the highest leverage is critical to the company's success.

4.2 Product Development Metrics

Performance metrics are part of a system that measures progress to objectives. They communicate achievements to management and facilitate cross-organization communication to enable decision-making. The first step in developing the high leverage set of metrics is to have an understanding of the process and what data is currently being collected to evaluate the effectiveness of the programs.

Hypothesis: Teams do not find value from all the metrics that they are required to use.

Figure 4.5 Metric Type and Usage by Program

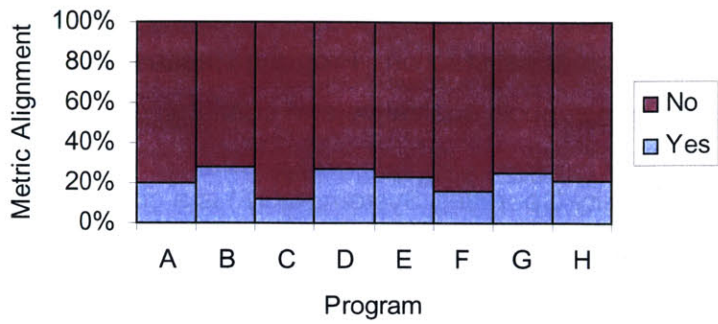


Teams were asked what types of metrics they used on their program. The results are shown in Figure 4.5. In the most extreme case, a program used seven different sets of metrics. Five types of performance metrics were the fewest that teams were required to use. Further analysis of metric categories used by the programs shows that many of the same types of data were required for reporting under these metric systems. However, the format of the data was dissimilar among the various categories. This suggests that teams must spend time modifying data to fit the reporting format of the various metric types. Subsequent discussions confirmed that teams spent substantial time reformatting data. The time spent the modifications to the format is non-value added work. This suggests inefficiency in the system given the limited resources.

Hypothesis: Performance Metrics are not aligned.

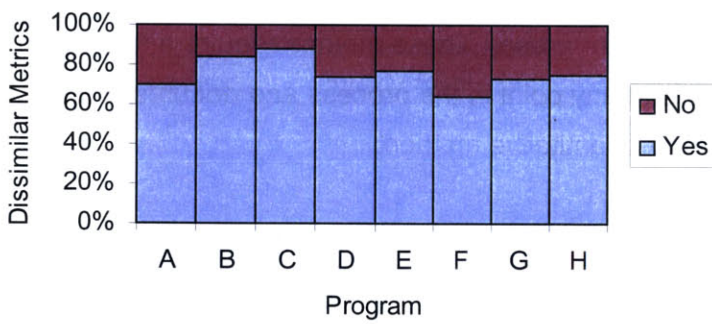
When asked if metrics were aligned, only 17% of individuals believed that all of the metrics that they used were aligned. Beliefs on alignment of metrics are shown in Figure 4.6 by program and support the hypothesis.

Figure 4.6 Metric Alignment



Hypothesis: Teams are required to use too many dissimilar metrics.

Figure 4.7 Dissimilar Metrics



The teams were also surveyed on their beliefs on alignment of metrics. Two thirds of the individuals believed that the teams were required to use too many dissimilar metrics. Data by team is shown in Figure 4.7.

4.2.1 Performance Metric Descriptions

Ford Product Development System (FPDS) Metrics represent a wide-ranging set of performance metrics including FPDS process metrics, Program Health Chart Metrics, Quality Operating System Metrics, Program Implementation Review Metrics and a subset of Functional Metrics. FPDS provided an integrated system that supports reporting and documentation of metrics and allows for program customization to include Program Specific Metrics. This on-line system was developed during reorganization and reengineering of Ford 2000 and represents the latest Product Development Process. Programs that were initiated before Ford 2000 used the earlier World Class Product Development Process.

Program Health Chart Metrics are the set of metrics that have been developed to support the senior management reviews and decision-making at specific milestones. Program Health

Chart Metrics were developed to provide a standardized format which are concise yet comprehensive. They are meant to support the strategic goals of the corporation and program by describing the team's progress in achieving competitive positioning, profitability and customer satisfaction. Program Health Chart Metrics are rated on a red, yellow, green scale and support qualitative and quantitative data.

The Quality Operating System (QOS) is a collection of data summarizing the quality performance of operations. They include the lower level operational detail on the process performance and progress toward achieving the deliverables required at each milestone as well as the detail that supports the qualitative and quantitative documentation of work. The QOS is a combination of new metrics and legacy metrics from prior processes including the World Class Process (WCP), the Product Development processor to FPDS.

Program Implementation Review (PIR) contains data driven metrics that measure progress to objectives. They evaluate the teams success to plan and, similar to the Program Health Chart Metrics, classify progress as red, yellow or green. These metrics require a team to have specific knowledge of where they are at any point in the process and document the progress toward the objectives using a very quantitative method.

Functional Organization Metrics are those metrics that are developed by organizations outside of the product development organizational structure. These functional organizations include Purchasing, Quality, Vehicle Assembly and Manufacturing, Powertrain Operations, Marketing and Sales and Service. Each of these functional groups has their own sets of metrics and/or specific quality operation system by which they report to their organization and chain of management.

Program Specific Metrics are developed by the team to support work effort that is focused on a specific product characteristics which addresses and incorporate unique parameters that the team deems necessary in supporting the Product Development Process. These metrics are widely varied and ad hoc in nature.

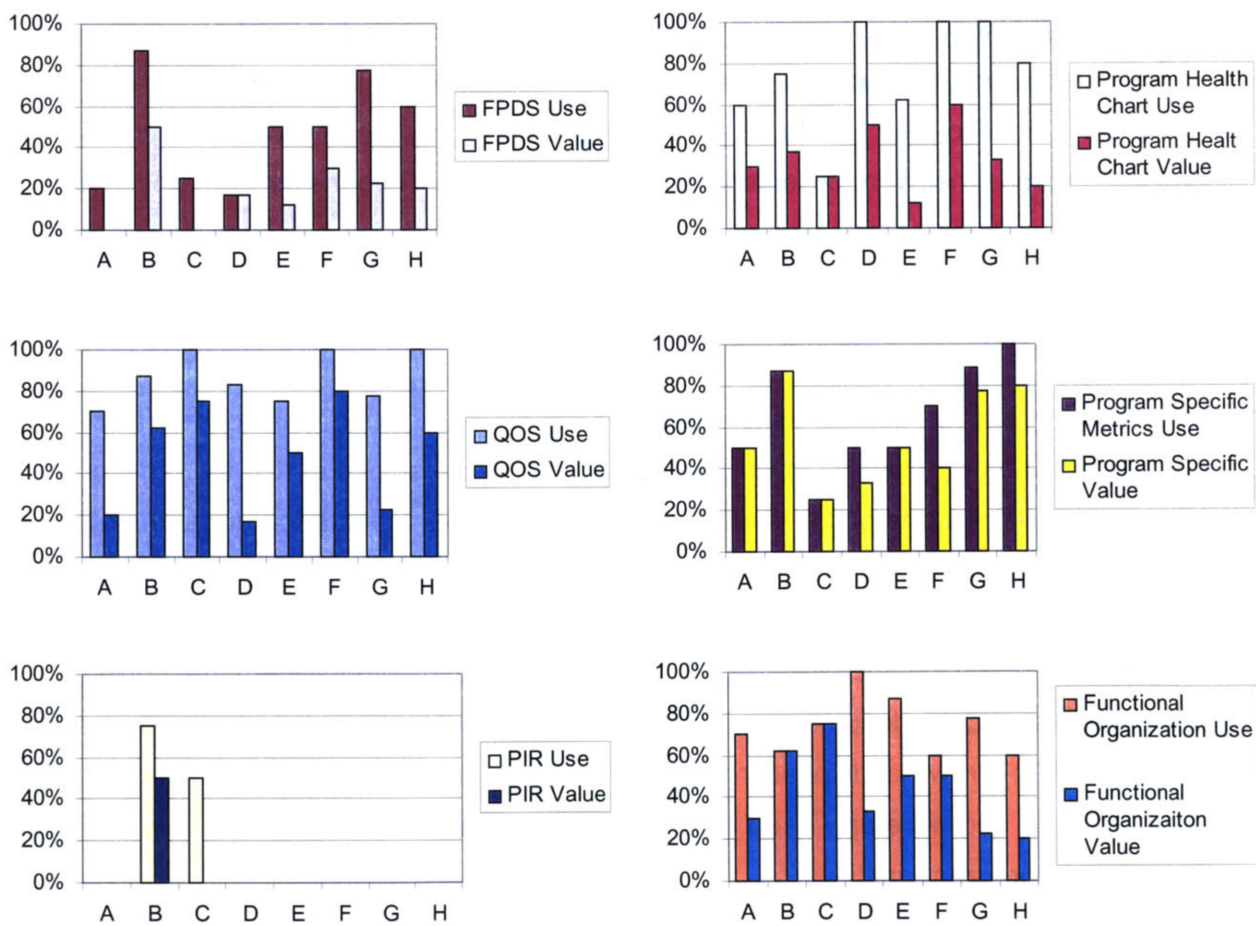
Individuals were asked which of the metrics that they found added value. Table 4.1 shows the individual responses. The most valued set of metrics were the Program Specific Metrics followed by Functional Organization Metrics and QOS Metrics. The least valued were the FPDS Metrics and Program Health Chart Metrics.

Table 4.1 Performance Metric Value

Performance Metric Value	Yes	No
Quality Operating System Metrics	54%	46%
Ford Product Development System Metrics	40%	60%
Program Implementation Review Metrics	50%	50%
Program Health Chart Metrics	45%	55%
Program Specific Metrics	83%	17%
Functional Organization Metrics (Manuf, Quality, APQP, other)	57%	43%

Similarly when looking at the value of metrics by program, Program Specific Metrics followed by Functional Organization Metrics and QOS Metrics were considered most valuable by the programs and the FPDS Metrics being the least valuable. Program response comparisons are shown in Figure 4.8 charts 1 through 6.

Figure 4.8 Performance Metric Use vs. Value by Program



The most interesting observation related to Performance Metric Used was that not all team members responded that they were aware of the use of certain types of metrics by the program. This finding supports the hypothesis that teams were required to use too many dissimilar metrics.

It appears that programs used different metrics in which to manage the program. Programs found the most value from QOS, Program Specific and Functional Metrics. It was interesting to note that in the categories of Program Specific and Functional Metrics, in general, had higher use to value scores than the other categories of metrics. The value of the Program Specific and Functional Metrics as compared to the FPDS, Program Health Chart and PIR metrics suggests that the metrics that the program uses to accomplish their tasks is more useful to the team than those metrics that are used to primarily for management reporting and decision-making.

4.2.2 Performance Metric Documentation

When looking at historical performance, comparable data were needed for the analysis. The only available comparable data that were discovered for the programs were those data documented in the Program Health Chart and functional organization reports and those data related to outcomes that were collected by staff organizations. Two things were postulated by these findings; 1) only those data used for management reporting and specifically tailored to be easily comparable were common among programs and 2) all comparable data were used to communicate to interfacing organizations the status of the program and progress.

Of the remaining sets of metrics, either data were not available or the types of data were not comparable. The Ford Product Development System was developed during the product development cycle of some of the earlier programs. Programs that started under the old World Class Process integrated some of the best practices from FPDS where they could. Similarly, the Quality Operating System used by programs differed due to the reengineering effort. Because of the significant changes, the online documentation system that currently is used for FPDS and QOS documentation contains complete data for only two programs and partial information for two additional programs. The Program Implementation Review Metrics are relatively new and were only used by two programs. Therefore, there were very few data to use for cross program analysis.

4.2.3 Performance Metric Analysis

Metric data can be grouped into two categories – one which measures product outcomes and another that measures internal process achievements.

Metrics that measure product outcomes include Shareholder Value, Program Timing[10], market research data which measures Customer Satisfaction and Things Gone Wrong (TGW) as well as warranty data of Repairs/1000 and cost per unit (CPU).

Metrics that measure process achievement include how well the team members met strategic goals (% green on health chart), how successful the team was at cost management, how successful the team was at achieving the functional attributes (PALS target), the success of bringing suppliers on board and communicating the program strategy which is measured using the Early Sourcing Target Agreements (ESTAs), the number of new technologies implemented by the program, the useage of carry over parts, the amount of assembly and manufacturing reusability, how many parts received a Parts Submission

Figure 4.9 Program Metric Correlation

	SVA	Program Timing (-)	Customer Satisfaction	TGW	R/1000	CPU	% Green on Health Chart	Cost Management	PALS Target	ESTAs	Technology - Program	%C/O	Ass/Manf Reusability	% PSW	DVPs Complete
SVA															
Program Timing (-)															
Customer Satisfaction															
TGW															
R/1000															
CPU			+		+										
% Green on Health Chart					+	+									
Cost Management	+														
PALS Target			+												
ESTAs		+			+	+	+								
Technology - Program															
%C/O						+				+					
Ass/Manf Reusability		+			+	+				+		+			
% PSW							+								
DVPs Complete					+	+	+		-	+					

[10] Note: The Table 4.9 shows that the positive direction is better with the exception of program timing (e.g., As ESTAs goes up program timing goes down)

Warrant (PSW) on time, and the number of tests completed on time. Correlations were identified for each pair of measures. Figure 4.9 shows where there is strong positve or negative correlation among metrics.

The first six measures represent outcomes with the remainder being internal performance measures. The performance measures can be divided into three categories: a) outcomes that are correlated with outcomes, b) internal metrics that are correlated with outcomes, and c) internal performance metrics that are correlated. The strongly correlated measures among outcomes were Customer Satisfaction with the warranty measument of Cost Per Unit (CPU). Both warranty outcomes of CPU and R/1000 had strong correlation with each other. Several internal performance metrics are strongly correlated with the outcomes: Cost Management with Shareholder Value; ESTAs and Assembly and Manufacturing Reusability with Program Timing; PALS targets with Customer Satisfaction; and ESTAs, % CarryOver, Assembly and Manufacturing Reusability and DVPs Complete with the warranty measures of CPU and R/1000. In addition, several of the internal performance metrics were strongly correlated with each other.

To gain a better understanding of how program teams used performance metrics, the Program Health Chart data were examined. There are eighteen categories of measures including four specifically related to financial analysis. Figure 4.10 shows Program Health Chart results by program. None of the programs were 100% successful in achieving their program goals. Each program experienced some difficulties during the Product Development Process. Success and difficulties are described in greater detail below.

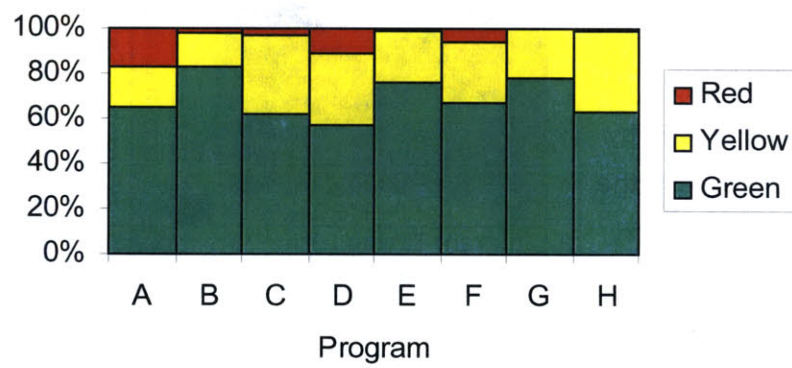


Figure 4.10 Program Health Chart Results by Program

4.2.3.1 Performance Metrics General Comments

Many of the teams provided comments regarding the team's experience with the various program metrics. Despite the shortcomings of the numerous and varied metrics, the program teams believed that performance metrics provided the tools to prioritize, communicate and tailor the program deliverables and provide discipline and focus to the team's activities.

Program A used product development metrics to prioritize and focus the team on the most important tasks. The program stated — "Too many metrics confuses the team and dilutes the 'sense of urgency'. During crunch-time, the team needs to maintain a clear focus on the highest priority issues. Consolidate all of the various tracking systems into a document [system] for prioritization purposes." Because of the large number of performance metrics, the team combined the various metrics and used the most important few to focus and guide the team.

Program-specific tailoring of the metrics was a common theme among programs. Program B was one of the first FPSD programs to use the new product development metrics. Although the team was required to develop and tailor the metrics, the program believed that by using metrics the program was able to achieve a larger percentage of green deliverables. The program states – "Program management tools such as FPDS and QOS require program enhancement. Predictive QOS metrics must be made available. Program templates should align to the QOS deliverables. Once Program Specific QOS Predictive Metrics were established, the QOS was fully implemented with the team developing and tracking program specific predictive metrics for critical deliverables. The implementation of the QOS has enabled the team to maintain focus and achieve a high success rate of green deliverables. Ensure timely development of predictive metrics prior to preceding gateway to maintain workflow and identify shortfalls to process deliverables in time to implement recovery actions." Similarly, Program C believed that a "combination of program complexity, new processes and new organization resulted in insufficient robustness within work plans, requiring repeated implementation of recovery actions. QOS process & metrics, adoption of a new program management process and the associated learning and application, particularly for detailed metrics that were not fully refined, has been a challenge. Familiarity with and development of metrics tailored for the program has improved and will provide benefits for future programs in early development." Clearly, the documentation and refinement of the performance metrics can enable future product development teams to accelerate the product development process if those metrics remain stable.

Programs E and H used workshops to develop their program specific metrics and communicate them to the team. Program H states, "QOS workshops were used to prepare the team, to understand requirements and to customize deliverables and metrics. The customization of deliverables tended to be revisited due to a lack of clarity of requirements and in some instances a steep learning curve." Rigorous definition and clear communication of the deliverables are essential to successful outcomes. Program E expresses the need to "conduct early QOS workshops with entire team to obtain consensus on objectives and requirements. Two-way communication must occur with all potential customers when developing total program vehicle requirements. Through construction of a detailed vehicle program plan and customization of the QOS and team specific deliverables for each FPDS milestone, the program was able to achieve their timing." Performance metrics can provide a means to communicate vital information to the team and outside organizations.

Program G used metrics to provide discipline — "Understanding key deliverables and planning helped the team achieve accelerated program timing. FPDS and QOS deliverables have focused the team on critical processes. Adherence to the targets process is critical to achieving compatible vehicle level targets. Increased team discipline is required in programs with accelerated timing to achieve deliverables on schedule." By providing structure and prioritization, the team was able to use performance metrics to manage changes to the program timing and assumptions.

4.2.3.2 Program Timing

Program Timing was an outcome that was determined by the strategic goals of the firm. Variation in stated program timing was attributable to management intervention. These management interventions were due to strategic decisions, internal capacity issues or because the program did not achieve the goals required to proceed through a milestone. An example of how a strategic decision impacted a program can be shown by analysis of Program D. Program D was required to take six months out of the product development process. The team states, "accelerating the program and [the addition of] new corporate requirements required the team to find offsets, which consisted primarily of program content, in order to meet the ABS[11]". This caused rework in the program. Late in the program, the team was asked to add content back in. A quote from Program D sums up the impact of these directions on timing..."Program timing pull-ahead and added content late in the

[11] Affordable Business Structure (ABS)

program significantly increased the program workload and added substantial program risk." Analysis of the survey results shows that Program D had a highly iterative process. These disruptions caused the team to revisit work that had already been done, resulting in a more resource and time-intensive process.

4.2.3.3 Shareholder Value

The rigor of the financial analysis and the outcome of Shareholder Value are directly related. Based on the historical emphasis on financial controls, the alignment was not surprising. When financial targets were not achieved it was either due to a softening of the market that resulted in lower programmed revenues/volumes than expected or there was an internal intervention that extended the duration of the program and adversely impacted the Affordable Business Structure. Program B experienced a softening of the market and states "due to revisions to the Marketing Equation, a 19% reduction in volumes and a 3% reduction in net revenue has been experienced since the last milestone—equivalent to 50% of the ROS target. The program teams should be more conservative in initial vehicle level target setting to allow for wide variations in the Marketing Equation." Program H experienced an internal intervention that delayed resource staffing the result was "...poorly defined statements of work, late signing of target agreements and lack of supplier reviews led to build issues and discrepancies between the projected and actual costs". Programs that got into financial trouble and reported red on the Program Health Chart, tended to have difficultly throughout the remainder of the program.

4.2.3.4 Quality and Customer Satisfaction

Analysis shows that teams were not successful in predicting the outcomes of the market research measures of Customer Satisfaction and TGW, nor were they successful in predicting the outcomes of warranty measures of CPU and R/1000. Programs based their forecasts on historical trends with an adjustment factor based on predictions of program design enhancements.

Even though the teams were unable to accurately predict the actual market research and warranty numbers, the teams had a subjective "feel" for the outcomes. Program A had the highest warranty costs and knew in advance that late changes would adversely affect the outcomes. The program cites as one of the lessons learned that "late program changes ...are expected to cause confusion and lead to higher repair and warranty costs and dissatisfy our customers. We need to prevent late changes by adhering to our processes."

Teams that focused on robustness and reliability were more accurately able to gauge their design improvements. Robustness and reliability methods may be more appropriate means of assessing product improvements. Program D stated that their success was from the "use [of] robustness training techniques in the design of components, maintaining a QOS and monitoring the program's [status by] using reliability growth curves". By measuring improvements that make the design insensitive to noise and by improving measurements such as mean time to failure, programs can quantitatively assess the product development and improve customer satisfaction. This hypothesis will be modeled and analyzed in the next section. In all cases, what the program reported on the Program Health Chart as status to objective did not correlate with the actual outcomes of Customer Satisfaction or warranty.

4.2.3.5 Understanding the Customer

Programs that took the time to understand the customer were more successful in the outcome of Customer Satisfaction. Program E ensured that ..."team members conducted one-on-one customer interviews and attended clinics to learn about customer likes, dislikes and preferences". They cited that it was important to ..."understand customer expectations fully and set functional targets accordingly to help determine which aspects of a vehicle should be carryover – customer needs [were] realized late in the program and impacted strategic assumptions for C/O and costs. Understanding of the market was facilitated by dealer discussion when large-scale research was cost prohibitive. Competitive vehicle evaluations by the team helped to define current market trends. The team conducted early market research clinics to determine overall vehicle architecture and key feature assumptions". . Program A used Quality Functional Deployment (QFD) methods to develop customer driven requirements and gained an understanding of the market through functional image benchmarking. Program A and Program E were most successful in meeting the customer's needs and receiving high satisfaction scores.

4.2.3.6 Functional Targets

Functional Targets had a strong correlation with Customer Satisfaction. The data suggested that when programs focused their efforts not only on identifying the vehicle targets but also on understating where those targets were to competitive vehicles in the segment, the overall result was better customer satisfaction. Program B recommends, "Program Teams should ensure targets are driven by customer and competitive requirements. Further work is required to correlate customer satisfaction data with objective metrics and drive teams. Not all functional and financial targets were cascaded simultaneously, resulting in functional and financial target incompatibilities. This required intensive actions to establish compatibility late in the process. Teams should follow the target cascade process and cascade financial and functional targets simultaneously. This will ensure compatibility prior to next level of cascade." Program C believed a "target driven design/development process [enables] the cascading of customer wants into technical targets and system/sub-system target tracking, forming the basis for identifying root causes for functional concerns and developing robust, customer focused corrective actions. The ESTA process [was] utilized to establish target costs consensed with suppliers and consistent with the Affordable Business Structure—subsequent monitoring of target achievement through design development, and continuing through to launch" was key to achieving the team's goals related to Shareholder Value.

4.2.3.7 Analytical Tools

Many programs used analytic tools in place of prototypes and testing. Program G used analytical methods beginning with the selection of the vehicle architecture – "Up front CAE work is instrumental in the vehicle architecture selection process. Use competitive vehicles to establish design requirements. Maximize the use of CAE evaluation of a design's functional parameters. Use FRG to ensure robustness methods drive the development of the design. Evaluate objective functional requirements from component to vehicle level." Program E "utilized customer priorities and PALS leadership early in program". The program states there is "value in having competitive benchmark data on which to base functional and financial targets. Early team competitive vehicle evaluation was successful in defining the current market trends. Earlier development of financial comparator model to develop appropriate investment and variable cost targets is necessary. Make more use of upfront analysis tools and allow for investment and variable cost provision for changes to carryover part. ESTA and PPL needed to facilitate communication and develop accurate financial and functional targets. CAE enabled reductions in prototype costs and tooling by proving out designs early in the program, which allowed for greater number of production tooled parts to be available sooner. Costs were reduced by use of CAE/CAD and resulted in minimizing prototype tools and parts." Program D was also successful in achieving early verification of targets through the use of CAE. The program states "extensive benchmarking and target setting was done early in the program and formed the basis for the DVP. CAE plans that defined the application plans, model definition and input data quality were developed and controlled to assure timing and usefulness of the results. CAE driven design makes available up-front adoption of CAE design and evaluation tools in advance of hardware availability were particularly successful ... Prototype performance is meeting/exceeding most program targets." Programs benefited from CAE/CAD technology using it to analyze and verify targets. Program A said that "attribute groups relied on CAE methodologies to establish performance targets and drive the design. Prototype process to reduce expenditures [were] addressed by CAE and functional attributes established by cross-functional teams and driven by CAE in assessing ability to achieve targets. Good correlation between up-front modeling and testing was achieved." When teams were successful in establishing and cascading targets and using analytical tools, the results were higher Customer Satisfaction and Shareholder Value.

4.2.3.8 Supply Plan

Programs that developed supply plans, developed statements of work and signed Early Sourcing Target Agreements were more successful at meeting program timing and effectively completing testing that led to lower warranty costs. Surprisingly, ESTAs and PSW did not have a significant correlation (Correlation = 0.8 with Rsquare = 0.63 Prob>F = 0.21). This is believed to be attributable to the small sample (n=8).

Programs used the ESTAs to document agreements on targets and communicate with the suppliers. Program C states "although [this program] has been the launch program for the ESTA Process, in general ESTA's have proved to be a powerful tool for assignment of affordable and compatible targets, and negotiation with the supply base. There has been a refreshing willingness within both the team and the suppliers to jointly commit to targets and the statements of work required by the ESTA." Documentation of agreements on targets and timing benefited Program G. This team states that "functional targets need to be cascaded to the lowest appropriate level to allow on time completion of the target approval process. A disciplined use of the Early Sourcing Work plan has given the team a common database and communication medium. Establishing a PPL is a key document in focusing the team, as are the SOWs." Similarly, Program D emphasized the importance of ESTAs as a communication tool – "ESTAs must be revised when program direction and content is revised. Ford and its suppliers need to continue replacement of the traditional OEM-Supplier relationship with a new 'colleagues collaborating' relationship. Robust statements of work were developed and resulted in higher quality ESTA process."

4.2.3.9 On-time Testing

On-time testing was correlated with success in achieving ESTAs. It appeared that when programs were able to identify suppliers early in the program and to sign target agreements, the more success the team had in completing testing. Similarly, there was strong inverse correlation between DVP and achieving targets. Programs that had more stretch targets were less likely to have testing completed on time. On-time testing also correlated with lower warranty costs.

4.2.3.10 PSW Parts

The percentage of PSW parts correlated strongly with percentage Green on the Health Chart. It appears that several factors need to come together for a team to be successful, including the program's strategy, compatible targets, a robust supply plan and achieving on-time testing.

4.2.3.11 Technology Strategy

Technology strategy on the program had high correlation with the percentage of carryover part and assembly and manufacturing reusability. Programs B and F believed that the "new technology was not sufficiently ready for implementation on the program. The technology required a high degree of development by the program". Program E cited that "implementation readiness was not achieved and parts need to be tested under all operating conditions, especially new technology parts". It appeared that the programs that implemented many new technologies focused their resources on the development and implementation of those technologies and leveraged a high degree of carryover content that did not require a significant number of resources.

4.2.3.12 Manufacturing Strategy and Carry Over Parts

Analysis shows that the programs with higher manufacturing and assembly reusability tended to have a greater percentage of carryover parts. Also, the higher the reusability, the shorter the program timing and the better the team did on warranty. Program D "began managing the reusability and carry over strategy early. Manufacturing co-located with product development to increase the exchange if ideas and to drive early assembly issue resolution. Focused, labor and process reviews resulted in lower labor, assembly improvements and product quality improvements". Program E suggested that the team's success was because it provided "upfront reusability training for program team support and understanding and involved all of the stakeholders in advance assessments of reusability tradeoffs." And, Program E stated that teams should..."fully understand customer expectations and functional targets to determine which aspects of a product should be carried over on the vehicle. Assumptions for C/O components and systems did not fully take into account the customer requirements. At the appropriate milestones, understand the customer expectations fully and set functional targets accordingly to determine which aspects of a vehicle should be carried over to the derivative."

4.2.3.13 Resources and Communication

While there were no performance metrics that measured the team's effectiveness in the area of recourses or communications, the common theme around resources was co-location. Although, all of the teams were co-located, co-location itself did not prove to be the only factor in effectiveness. Differences existed in the way teams managed resources. The types of comments that were available in the lessons learned provided quite a bit of insight. The first and most striking observation was that the teams, which were the most successful, provided comments on areas that they believed were key to the team's achievements. These programs – D, E and G – provided insights to the ramp up of resources, knowledge and expertise, training, communications and meetings. The remainder of the teams struggled with managing resources. Below are excerpts from programs giving wisdom on how resources were managed during the Product Development Process.

4.2.4 Ramp up of Resources

The two most successful programs cited the importance of staffing. Program G succinctly summarizes the point— "Quick ramp up of personnel and co-location of the team is critical to the team's success. Program E said that "... rapid staffing of CAE is mandatory to avoid delay in integrating CAE into product design and development. Events from FPDS need to be revisited and reconciled with team staffing models and FPDS timing plans. Both teams realized the benefits of understanding what resources are needed and staffing the program appropriately.

4.2.4.1.1 Experience and Depth of Product Knowledge

The more successful teams believed that experience and depth of product knowledge helped to shape the outcomes of the program. Program G said ..."Placing team members on the program who have previous experience in FPDS programs facilitated the knowledge and successful ramp up of the overall team". An observation that was made by Program D was— "Dedicated resources that continue throughout the program were more successful than resources that were shared with the advanced vehicle organization and spilt up after a period of time". Both teams appeared to realize that expertise in the product and the process help to build a cohesive, well-functioning team.

4.2.4.1.2 Training

The high performance teams, Program D, E and G, spent time on training and defining work roles and responsibilities. Program D insisted that "skill level and clear responsibilities are critical to success -- teams that spent time upfront training and clarifying R& R were more successful." When training was provided to team members, it helped to clarify roles and responsibilities as well as new processes. Program E states that "full team training [was] helpful in developing understanding of FPDS and role in the program." On time, program specific training made it possible to have a common team understanding. "Training team members coincidental with staffing ramp up and tailoring the course material to the specific program was successful" for Program G. Upfront training, clear roles and responsibilities and common understandings were reasons for Program D, E and G's accomplishments.

4.2.4.1.3 Communication and Communication Methods

Effective communication and innovative communication methods enabled the high performance team to align objectives and quickly resolve issues. Program D credited co-location – "Co-located team created efficiencies and supported program-timing pull ahead. Co-location has led to a cohesive rapport within the team where individuals are embracing common objectives. Team co-location concept worked well – improved communication, facilitated rapid identification and resolution of issues and fostered team atmosphere. Improved utilization of web-based systems improves sharing of key information between teams and locations to facilitate higher quality communications and reduced decision time." Efficient and effective communication kept the team moving and allowed resources to focus on the work.

Program D and G comments on meetings showed that meetings that were established with a stated objective and consistent schedule resulted in effective outcomes and timely resolution of issues. Program D stated "Monthly cross-functional team (Manufacturing, PD, marketing, purchasing, suppliers) meetings facilitated communication to identify and resolve program issues. Early and frequent interaction between PD and Marketing supported timely styling and vehicle feature content decisions. Hourly (plant) operator involvement during prototype phase allowed for early identification of assembly and ergonomic issues." While Program G emphasized "target setting and tradeoff processes are best accomplished with the complete team in an off-site process. Assumption changes are best managed at a target alignment meeting where all customer attributes are represented. Team members must have a consistent meeting structure and effective communication process to all members. Team members must deliver all the relevant facts at decision-making meetings to achieve success." Both teams organized standing meetings with specific agendas to communicate effectively with team members.

The more successful teams adopted innovative as well as conventional methods of communication. Program G stated, "Communication process needs to be sufficiently robust in distributing directional change information to dispersed team members. Team web page has been extremely helpful in increasing the team communications. Establishing a PPL is a key document in focusing the team. Lean Executive Review Process Best Practice was significant benefit to the program by allowing resources to focus on critical work." Program D used "cell phones enabled rapid real time response to issues. " Those teams that focused on the communication process achieved more productive results.

4.2.5 Resource Struggles

Programs A, B, C and H struggled with resource issues during the Product Development Process. Issues that impacted the program teams included the Ford 2000 reorganization, unclear roles and responsibilities, lack of individual skill levels and the availability of resources.

Program A had high Customer Satisfaction, lower Shareholder Value and a longer Time to Market. This program attributes these outcomes to the "reorganization impacts of Ford 2000 which shifted responsibility of many areas and resulted in confusion of R&R. Team also lost key skills, experienced team member and overall resources when adopting the new organizational structure. These changes have disrupted workflows. [The Team} should have conducted monthly meetings with Manufacturing (cost and investment) and Purchasing (ESTAS) to discuss current status vs. targets. Establishment of a cross-functional co-located team strengthens communication and a shared vision for the product. Open communication and common product vision is key to efficiently platform based product development. Early agreements on R&R organization structure and decision-making process are key to establishing a quality process. Clear simple product vision, buy in by management and clear translation of market requirements into specific customer wants helped the team to develop the vision and functional targets and communicate key issues directly to engineers."

Program C stated difficulties with the " many new organizational structures developed and launched during the Ford 2000 reorganization". The reorganization "caused some uncertainty and occasionally confusion within the program team, the Vehicle Center, and divisions. Overall, however, the Ford 2000 organization has significantly enhanced the commitment, teamwork, and focus of the program team, and supporting activities, which will deliver downstream benefits. Developing & Implementing New Processes, [Program C] has in many cases been the pilot for developing and implementing Ford 2000 processes, for example Affordable Business Structure, QOS, Compatible Targets process. The overhead for this [resources and timing] was not recognized at the outset and has needed significant team management attention. Co-located team personnel, including support activities, located together on same floors—dedicated Pictel facilities, in addition to other electronic systems support, facilitated communications. Formation of a co-located, dedicated team organization with the required cross-functional strength coupled with a weekly resource tracking process that ensured team staffing was achieved as required by the program plan."

Program B suffered from difficulties with co-location, training and roles and responsibilities – "Office co-location has consumed excessive team resources and required too many negotiations for the necessary space and equipment. The Pre-Program facilities must be ready at Program [initiation] with adequate space and equipment. Support organizations and sister activities did not receive sufficient training to identify their roles and responsibilities within the FPDS intent. Clear/consensed roles/responsibilities need to be defined through adequate training/awareness sessions with supporting activities implementing the new processes."

Program H suffered from difficulties with resource staffing that resulted in program delays in meeting deliverables and ultimately extended the program timing – "Cycle plan instability caused the team to slow down and stumble – key effects of instability include resourcing, changes to infrastructures and processes. Loss of resource support, interruption of co-location plans and loss of momentum on timing hurt the program. Strategic sourcing decisions led to a delay in the program timing and the signing of ESTAs. Formation of a tightly knit largely co-located team with good cross functional strengths generated a high capability for the formulation of fast track timing plans and for effectively addressing major issues. Budget restriction due to resource calendarization had a significant impact on the assumption resulting in thrifting of content and prototypes and a restructuring of the vehicle program. Three month stop on engineering resources showed feasibility and release – need to establish a dedicated, co-located team combined with a stable cycle plan."

4.3 Effectiveness Models

4.3.1 Program Data Factor Analysis[12]

Program performance data collected from program papers were used to identify the primary components associated with the variables. The factor analysis identified two principal components, the linear combination of the standardized original variables that has the greatest possible variance. This calculation resulted in two main components that, upon analysis, related to internal metrics and external metrics.

Table 4.2 Program Factor Analysis

Metric	Company	Customer
SVA	0.9941	
Program Timing (-)	-0.9300	
Customer Satisfaction		0.7833
TGW		0.9599
R/1000	0.9377	
CPU	0.8577	
% Green on Health Chart	0.9073	
Cost Management		0.9074
PALS Target		0.9892
ESTAs	0.8794	
Technology - Program		0.9892
%C/O	0.7009	-0.7133
Ass/Manf Reusability	0.8483	
% PSW	0.9827	
DVPs Complete	0.9398	

Hypothesis: Certain internal performance metrics are more valued by the company where others have higher value in the market.

Table 4.2 shows the results of the factor analysis based on historical data. Approximately two thirds of the metrics measure factors that are associated with internal or company aspects of the business while only one third are directly customer linked.

[12] Factor analysis provides a way to structure many variables and combine them into an arrangement of principal components that facilitates analysis. Each principal component reduces the dimensionality of the dataset and helps to discriminate between groups and detect outlying observations by using the first few components. This type of analysis is useful when there are many variables and when the original variables are highly correlated.

Performance metrics related to the outcomes of Shareholder Value, Timing and warranty were more valued by the firm. Each of these outcomes relate to the profitability of the firm. Factors related to the outcomes of Customer Satisfaction and TGW were more valued by the customer.

Internal metrics of % Green on Health Chart, ESTAs, Assembly and Manufacturing Reusability, % PSW and DVPs Complete were more strongly related to the success of the company. As discussed in the prior section, the systems effects within the product development process relate to these factors and influence the outcomes of timing and shareholder value.

The influence of percentage of carryover parts was almost equally weighted between the company and the customer but was diametrically opposed. This made intuitive sense. The higher the carryover parts, the fewer number of resources required to design the vehicle resulting in more value for the company. The higher the carryover parts, the less value the customer perceives in terms of new features and technologies.

The factors of Cost Management, PALS targets and technology were more strongly related to the customer. It was not surprising that PALS targets and technology were strongly related to the customer, however the cost management factor was a surprise. After considering why this factor was more closely related to the customer, it was speculated that the reason was tied to the offering price of the vehicle and the volume produced. Better management of costs has an impact on the market offering and an impact on the price. The higher the volume, the lower the purchase price that is charged to the customer.

The performance results as documented by the team showed that several of the internal performance metrics are more valued by the company where others have higher value in the market. This suggests that if teams focus on measuring and achieving the internal performance metrics of Cost Management, PALS Targets, ESTAs, Technology, %C/O, Assembly and Manufacturing Reusability, % PSW and DVPs Complete, they will be able to gauge the success both internally and externally.

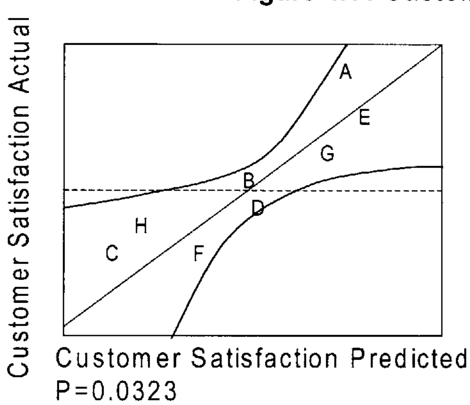
4.3.2 Outcome Models

The three internal metrics of Customer Satisfaction, Time to Market and Shareholder Value were modeled. These models were based on a combination of actual data and responses to the research survey.

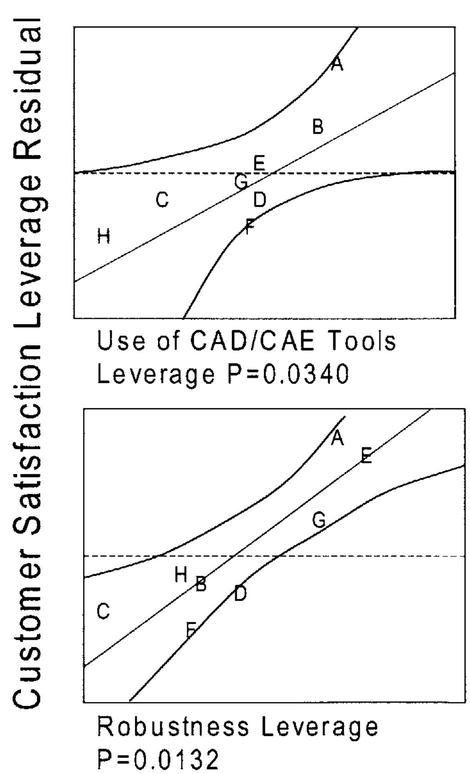
4.3.2.1 Customer Satisfaction

Customer Satisfaction was shown to have a very good fit with the use of analytical tools and robustness methods. The model shown in Figure 4.11 has R Square[13] value of 0.7466 and Prob>F[14] of 0.0323. It supports the hypothesis – Teams that use analytical methods have products with higher satisfaction. The model shows that the use of robustness methodology and analytical tools such as CAE and CAD has strong leverage on the outcome of customer satisfaction. The leverage plots on the left show the joint test of both the Use of CAE/CAD Tools and Robustness effects in the model. The Analysis of Variance table shows a

Figure 4.11 Customer Satisfaction Model



RSquare			0.7466	
Root Mean Square Error 0.0295				
	DF	Sum of Squares	MeanSqre	F-Ratio
Model	2	0.0128	0.0064	7.365
Error	5	0.0044	0.0009	
Ctotal	7	0.0172	Prob >F = 0.0323	



[13] R Square estimates the proportion of the variation in the response around the mean that can be attributed to the terms in the model rather than to random error.

[14] Prob>F is the probability of obtaining a greater F value by chance alone if the specified model fits no better than the overall response mean. Significance probabilities of .05 or less are considered evidence that there is at least one significant regression factor in the model.

significant F corresponding to this plot. The confidence curves show the strong relationship because they cross the horizontal line.

The two plots to the right of the model in Figure 4.11 show the leverage plot for testing whether Use of CAE/CAD Tools and Robustness is significant and show the contribution of each effect. The 95% confidence curves are shown in the plots. Note that the factor Use of CAE/CAD Tools does not relate as strongly to the response as the factor of Robustness.

The confidence curves in the leverage plot for Use of CAE/CAD Tools show that Use of CAE/CAD Tools is borderline significant because the curves are asymptotic to the horizontal line of the mean. Note that the significance of the Use of CAE/CAD Tools effect is .03, which is only slightly different from the .05 confidence curve.

The Robustness leverage line and its confidence curves cross the horizontal mean at a steep angle. The leverage plot for Robustness shows that Robustness is the most significant regressor with a significance of .01.

4.3.2.2 Program Timing

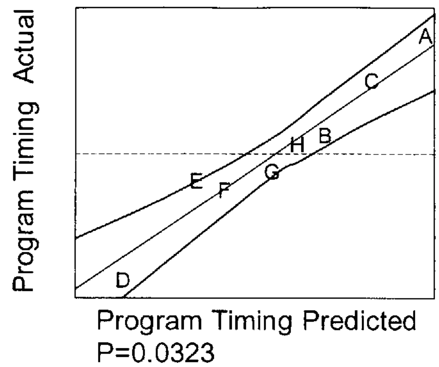
The next model of Program Timing looked at the impact of Manufacturing/Assembly Reusability and the nature of the Product Development process.

Customer Satisfaction was shown to have a very good fit with platform reusability and a stable, sequential process. The model shown in Figure 4.12 has R Square value of 0.9254 and Prob>F of 0.0015. The model shows that Overall Product and Process Interdependence have strong leverage on the outcome of Customer Satisfaction. The leverage plots on the left show the joint test of both Overall Product and Process Interdependence effects in the model. The Analysis of Variance table shows a significant F corresponding to this plot. The confidence curves show the strong relationship because they cross the horizontal line.

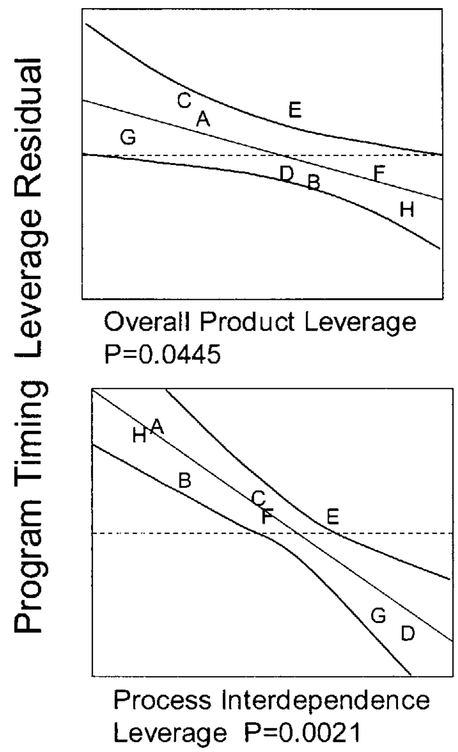
The two plots to the right of the model in Figure 4.12 show the leverage plots for testing whether Overall Product and Process Interdependence are significant and show the contribution of each effect. Note that the factor Overall Product does not relate as strongly to the response as the factor of Process Interdependence.

The confidence curves in the leverage plot for Overall Product show that Overall Product is borderline significant because the curves are asymptotic to the horizontal line of the mean.

Figure 4.12 Program Timing Model



RSquare			0.9254	
Root Mean Square Error .1814				
	DF	Sum of Squares	MeanSqre	F-Ratio
Model	2	2.0400	1.0200	31.002
Error	5	0.1645	0.0329	
Ctotal	7	2.2046	Prob >F = 0.0015	



Note that the significance of the Overall Product effect is .04, which is only slightly different from the .05 confidence curve.

The leverage plot for Process Interdependence shows that Process Interdependence is the most significant regressor with a significance of 0.002. The Process Interdependence leverage line and its confidence curves cross the horizontal mean at a steep angle. This demonstrates that a sequential Product Development Process with little rework is key to meeting Program Timing.

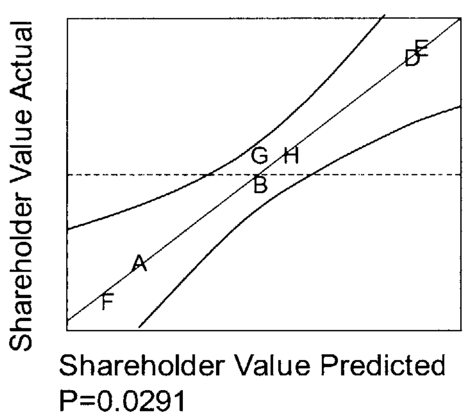
4.3.2.3 Shareholder Value

The model of Shareholder Value considered two factors, Assembly and Manufacturing Reusability and Cost Management. Shareholder Value was shown to have a very good fit with both factors of Assembly and Manufacturing Reusability and Cost Management. The model shown in Figure 4.13 has R Square value of 0.8977 and Prob>F of 0.03. The model shows that Assembly and Manufacturing Reusability and Cost Management have strong leverage on the outcome of customer satisfaction. The leverage plots on the left show the joint test of both Assembly and Manufacturing Reusability and Cost Management effects in the model. The Analysis of Variance table shows a significant F corresponding to this plot. The confidence curves show the strong relationship because they cross the horizontal line.

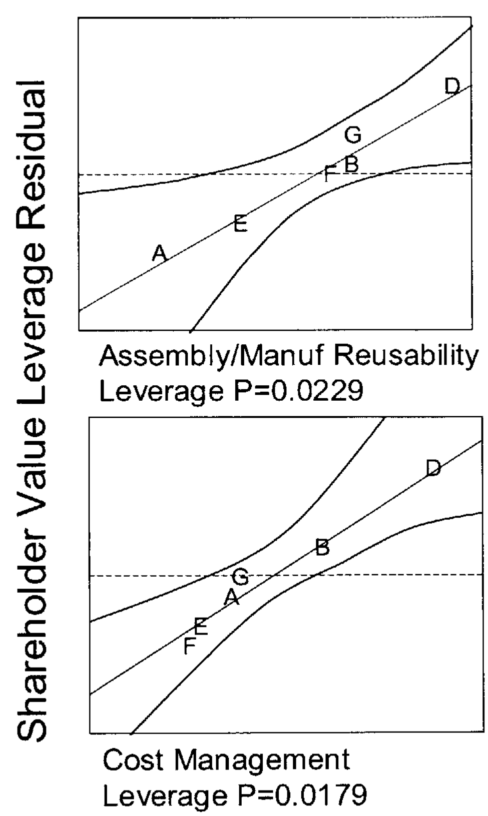
The two plots to the right of the model in Figure 4.13 show the leverage plots for testing whether Assembly and Manufacturing Reusability and Cost Management are significant and show the contribution of each effect. Both factors, Assembly and Manufacturing Reusability and Cost Management, are significant contributors to the response.

The confidence curves in the leverage plot for Assembly and Manufacturing Reusability show that Assembly and Manufacturing Reusability are less significant than Cost Management. The significance of the Assembly and Manufacturing Reusability effect is 0.022. The leverage plot for Cost Management shows that Cost Management is the more significant regressor with a significance of 0.018.

Figure 4.13 Shareholder Value Model



RSquare			0.8977	
Root Mean Square Error			0.0291	
	DF	Sum of Squares	MeanSqre	F-Ratio
Model	2	0.0223	0.0111	13.172
Error	3	0.0025	0.0008	
Ctotal	5	0.0248	Prob >F = 0.03	

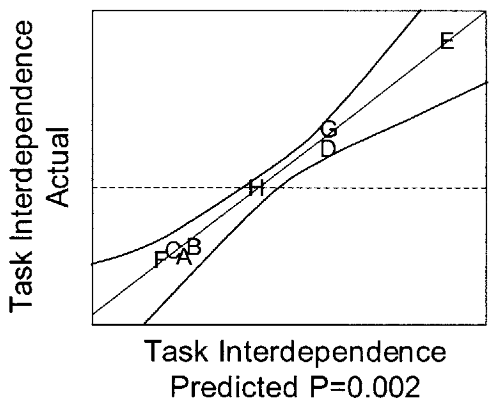


4.3.3 Effect of Organizational Structure and Timing on Task Interdependence

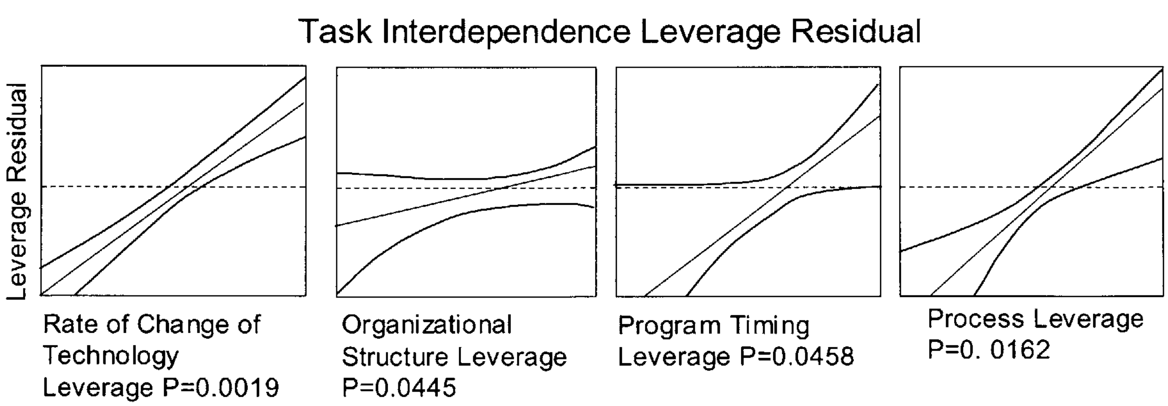
As mentioned before, Allen's work[15] highlights the parameters that must be considered when organizing teams. These parameters include the task/communication interdependence, the project duration and the rates of change of organizational knowledge and market factors. A model was developed to assess which factors most strongly influence the perception of task interdependence.

Task Interdependence was modeled as a function of the Rate Of Change of Technology, Orgranizational Structure, Program Timing and Process. The model shown in Figure 4.14 has R Square value of 0.9912 and Prob>F of 0.0020. The model shows that Technology and Process have strong leverage on the outcome of Task Interdependence. The leverage plots show the effects of the variables in the model. The Analysis of Variance table shows a significant F corresponding to this plot.

Figure 4.14 Interdependence Model



RSquare			0.9912	
Root Mean Square Error			.0575	
	DF	Sum of Squares	MeanSqre	F-Ratio
Model	4	1.1244	0.2811	84.946
Error	3	0.0099	0.0033	
Ctotal	7	1.1343	Prob >F = 0.0020	



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[15] Allen, Thomas J. (1997), "Architecture and communication among product development engineers", MIT Working Paper.

The four plots below the model in Figure 4.14 show the leverage plots for testing whether the variables of Rate Of Change of Technology, Orgranizational Structure, Program Timing and Process are significant and show the contribution of each effect.

The confidence curves in the leverage plot for Rate Of Change of Technology show that Rate Of Change of Technology is the most significant regressor with a significance of 0.002. The confidence curves in the leverage plot for Organizational Structure and Program Timing show that Organizational Structure and Program Timing are borderline significant because the curves are asymptotic to the horizontal line of the mean. Note that the significance of the Organizational Structure effect is .0445 and the Program Timing effect is .0458. The leverage plot for Process Interdependence shows that Process Interdependence is an important regressor with a significance of 0.002.

The model shows that Task Interdependence is a function of the rate of change of Technology and Process. According to Allen, if the program time duration is large, the preference is toward functional alignment. Allen also suggests that a high degree of interdependence suggests a preference toward the project team structure; lower interdependence suggests a preference toward a functional team structure. Because the programs were all long in duration, Program Timing did not have a large effect. Similarly, Organizational Structure was not a significant factor in the perception of Task Interdependence. This could be due to the fact that all of the teams were a subset of the corporate organizational structure. This suggests that teams, although working in a matrix structure, have realized that the Programs must maintain a functional focus to maximize team effectiveness. Correct partitioning of work, a structured plan to develop people and their functional expertise and reducing cycle time will improve team effectiveness in designing and developing vehicles and strengthening the corporate capabilities.

4.3.4 3D (Technology, Market and Process) Model

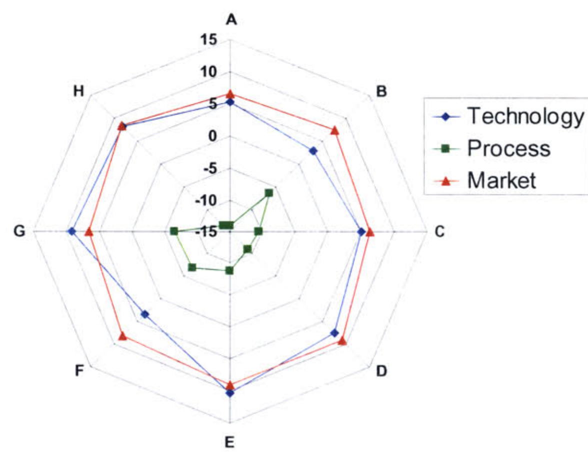
It was theorized that organizations, which are strong in the three dimensions of technology, process and market, perform better than organizations with lesser performance in any of the three areas. This concept can be translated to reflect the work within an organization and be applied directly to a Program Team. If teams are able to focus their strategic energy in such a way as to maximize the team's performance on all three of the dimensions, successful outcomes can be achieved

Hypothesis: Programs that are strong in all three dimensions of technology, process and market perform better than teams with lesser performance in any of the three areas.

A factor analysis was performed using seventeen survey questions. Three principal components were found and used to develop the model. These principal components were related to technology, process and market. Each value for the principal components was calculated by program and is shown in Table 4.3. The spider chart on the right shows in graphical form the relative scores for each factor by program. The larger the value of the factor, the stronger the emphasis the team placed on that factor.

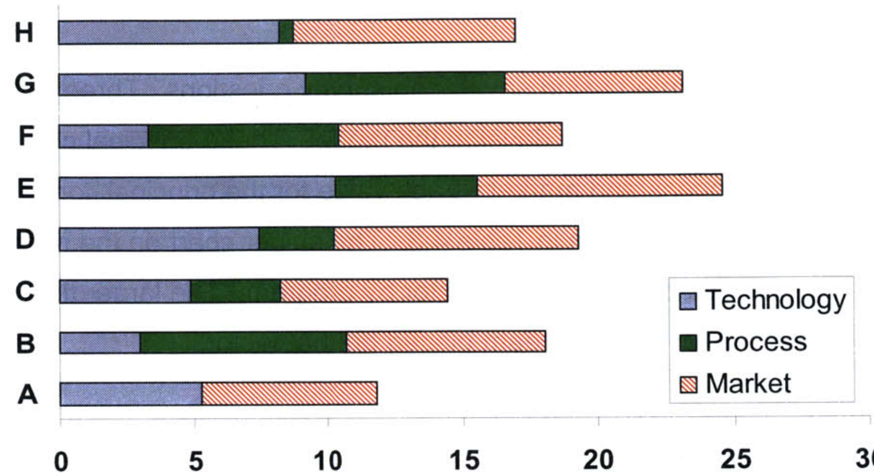
Table 4.3 Principal Component Values by Program

Program	Technology	Process	Market
A	5.273	-14.003	6.557
B	3.033	-6.335	7.314
C	4.899	-10.669	6.241
D	7.435	-11.160	8.980
E	10.351	-8.790	8.981
F	3.304	-6.829	8.236
G	9.233	-6.627	6.532
H	8.231	-13.498	8.288



These principal component values were analyzed. Figure 4.15 shows the results of the analysis using a stacked bar chart. Because the Process factor was negative, these values were adjusted to non-negative values. The modification enabled graphing and shows the relative differences among programs. A table is shown at the bottom of Figure 4.15 with the modified values.

Figure 4.15 Technology, Process and Market Model



Program	A	B	C	D	E	F	G	H
Technology	5.273	3.033	4.899	7.435	10.351	3.304	9.233	8.231
Process	0	7.668	3.334	2.844	5.213	7.175	7.376	0.505
Market	6.557	7.314	6.242	8.980	8.981	8.236	6.532	8.288

The teams that scored higher on the factor of technology were Programs D, E, G and H. The range of reported technologies implemented on the program was between three, the absolute minimum number of technologies reported, and eight, the maximum. It was surprising that the team that reported in documents as having the least number of technologies fell within this category. The other factors that comprised this component (technology development status, task interdependence, rate of change of technology, CAE/CAD tools, reliability and robustness) raised the overall value. The teams stated that they had a mix of proven and implementation-ready technology. These teams also reported that they had lower task interdependence, meaning that they felt there were fewer inputs required to complete a task. Scores were varied in the use of tools and methods. It was not surprising that Programs D, E and G, the most successful programs, scored high in technology. Program H, however, was a surprise. Further investigation into the reason why this team scored high led to inconclusive findings as to why the program had relatively high scores in this category. The only conclusion that can be made is that the other teams cumulative scores were lower when considering all of the factors. This anomaly could also be a result of the survey itself or the beliefs of individuals who responded.

The teams that had higher scores on the factor of process were Programs B, E, F and G. These programs developed the vehicles under FPDS the re-engineered Product Development Process. Notwithstanding the fact that the teams were using a newly developed process, they reported that the process itself was more sequential than iterative. These programs also reported that they received skilled resources as compared to the other programs responses that the resources did not have all of the skills required. Programs A and C had delays to market. Program D was pulled ahead. In general, the programs that scored higher in this category were the programs that had conventional development timing and that were completed using FPDS Processes. Although they scored well on Process, both Programs B and F had relatively low Technology Scores.

The teams that had higher market factor scores were Programs D, E, G and H. These programs were a mix of derivative products and new platforms. The programs were developed for growing segments that had many new entrants in the segments. There was not enough variation in the other factors to make definitive statements about one program versus another. Programs D, E and G had higher scores and positive outcomes. Program H's high score in the area of market was not surprising. This vehicle was developed for multiple markets. The vehicle was relatively more successful in other markets but missed its mark in the North American market segment.

Programs E and G were higher on all three dimensions of Technology, Process and Market. These programs were most successful on the outcomes of Customer Satisfaction and Shareholder Value. Both programs were also the only two programs that finished in the specified time; programs D and F were pulled ahead while Programs A, B, C and H were late to the established timing. This suggests that when programs score higher in all three areas of Technology, Process and Market, they will achieve the desired results. This also suggests that performance metrics can be strategically used to move the organization toward proper alignment of people, product and process by focusing on these three high leverage factors to achieve successful outcomes.

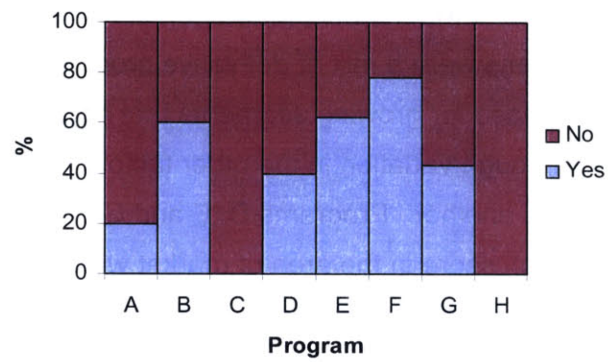
4.3.5 Alignment of Work Effort, Objectives and Compensation

The data collected from the research survey asked individuals to break down their stated objectives and compensation into five categories – people development, process implementation, cost reductions, profitability and customer satisfaction. Each was also asked to provide the percentage of his/her day-to-day work effort that was focused on the five areas. Individuals were also asked if they felt that their yearly objectives, compensation and work effort were aligned. These data were used to analyze the five hypotheses related to alignment of work.

Hypothesis: Individual work effort, objectives and compensation are not fully aligned.

Of the people who responded, 43% said yes and 57% said no. These data supported the hypothesis.

Figure 4.16 Individual Responses on Alignment of Work Effort, Objectives and Compensation



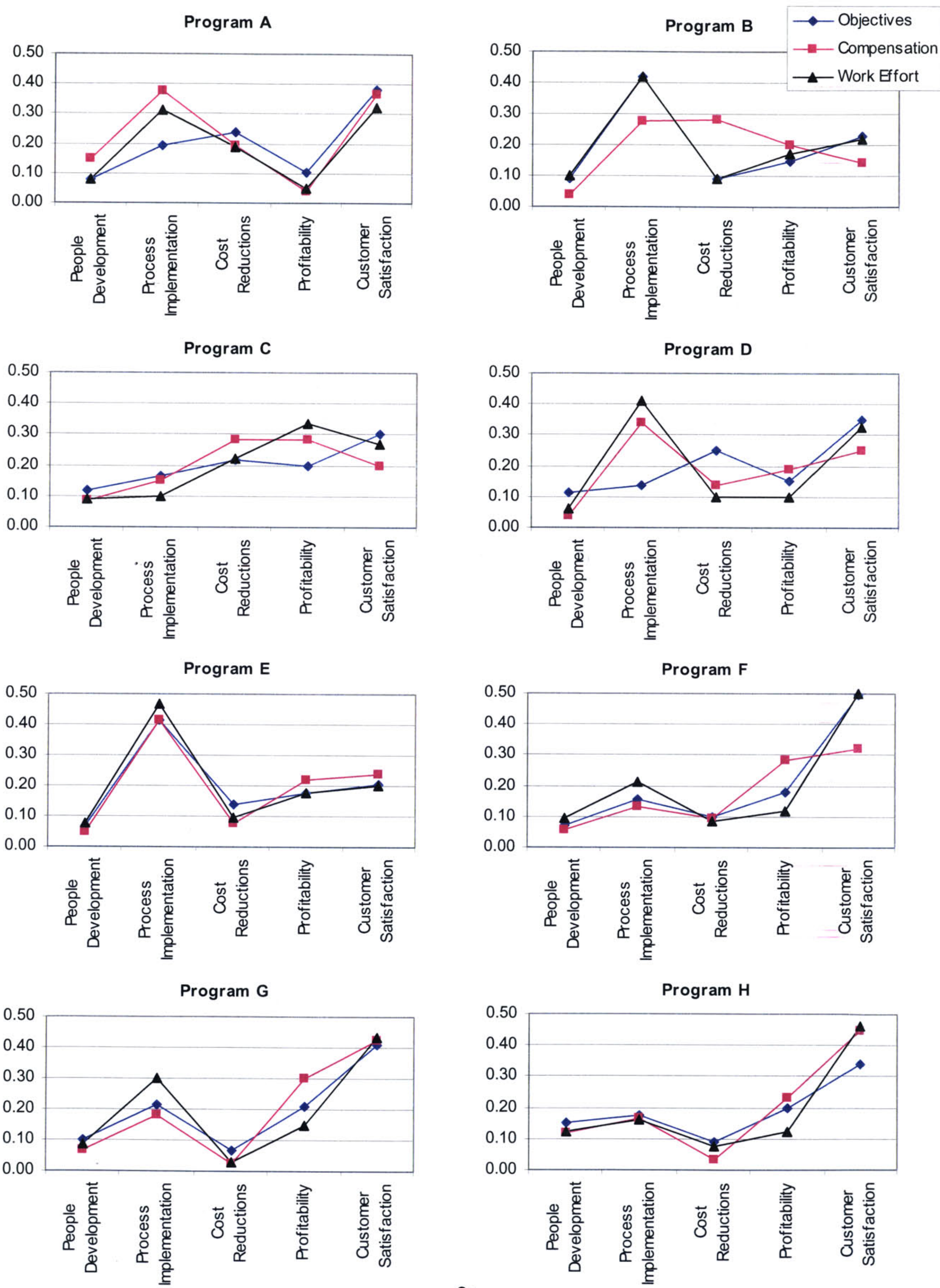
Individual responses were separated into program grouping and responses were then analyzed by program. Figure 4.16 shows the relative program responses based on individual responses. There were significant differences in the responses by program. The team responses did not conclusively demonstrate that the more successful programs had greater alignment of objectives, compensation and work effort. However, further analysis of the detailed responses yield interesting observations.

Figures 4.17 1-8 show the alignment of objectives, compensation and work effort for each of the five categories. Attachment 2 contains the data on alignment of work effort, objectives and compensation.

Hypothesis: Teams with greater alignment of objectives, compensation and resultant work effort are more successful with outcomes of customer satisfaction and shareholder value.

This hypothesis is based on the assumption that when people on teams work together toward the same goal they will achieve it more successfully than teams that have individuals

Figure 4.17 Alignment of Work Effort, Objectivities and Compensation

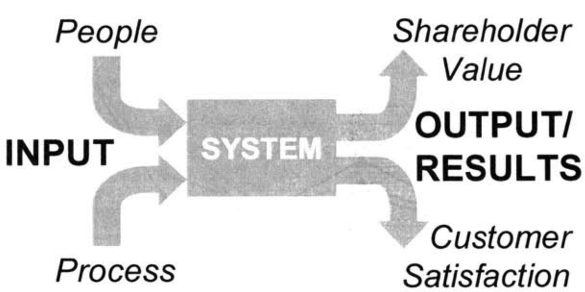


working toward different purposes. Programs D, E and G had the most successful outcomes. Programs E, G and H had greater alignment of objectives, compensation and resultant work effort as compared to the other programs while Program D had the greatest variation. Therefore, it cannot be concluded that alignment alone equates with successful outcomes.

When this data is compared to the data in Figure 4.16, the cumulative responses by program, there are many inconsistencies. Figure 4.16 indicates that individuals working on Programs F, B and E perceived that their objectives, compensation and work effort were more aligned while all of the individuals working on Program C and H stated that that there was little or no alignment of objectives. Without additional inquiry into the reasons why there was such a difference in perceptions on the alignment of objectives, compensation and work effort, no conclusions can be drawn from the results.

Hypothesis: Teams that have higher emphasis on people development and process implementation will have more successful outcomes.

Figure 4.18 Product Development System



People and processes are inputs to achieving specific outcomes as shown in Figure 4.18. Customer Satisfaction and Shareholder Value are the outcomes or results that the program strives to achieve. Programs that had higher focus on process achieved more successful outcomes. A review of the data shows that there was little focus, about 10% of effort, on people development. Development of people may have leverage on the overall outcomes. Currently there are not enough data to draw any conclusions on the impact of people development on the program. Since the programs all had similar responses to people development, the process implemenation dimension can be relatively compared. Again, Programs D, E and G have a higher emphasis on process implementation suggesting that focus on process implementation has high leverage on outcomes.

Hypothesis: Teams that have higher work effort in the area of customer satisfaction, performed better on the outcome of customer satisfaction

This hypothesis assumed that there would be direct correlation between work effort and outcome. The data show that this does not hold true.

Hypothesis: Teams that have higher work effort in the area of shareholder value, as measured by cost reductions and profitability, performed better on the outcome of shareholder value.

This hypothesis assumed that there would be a direct correlation between work effort and outcome. Similar to customer satisfaction, the data show that this does not hold true.

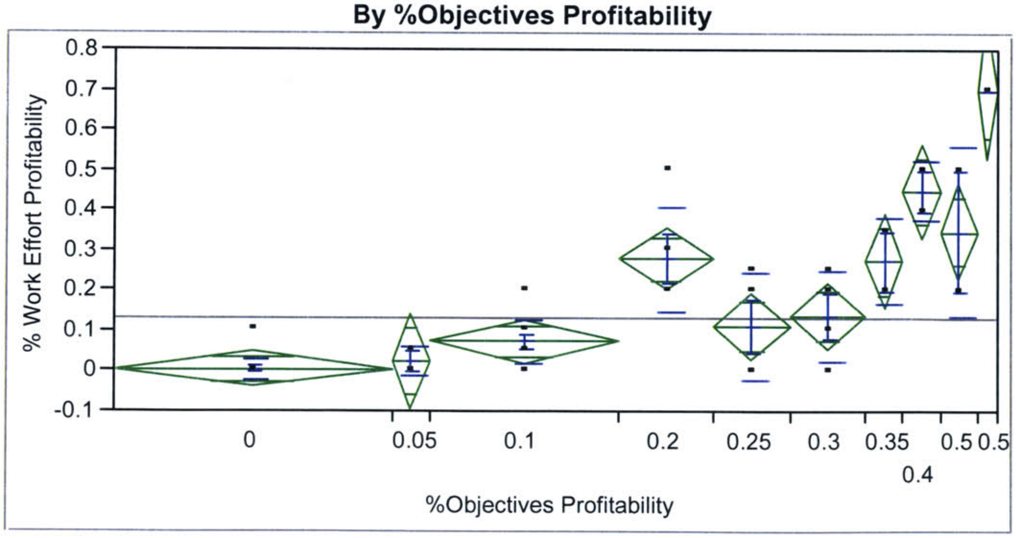
These findings suggest that the greater influences on outcomes revolve around the organizations focus on the people and the process and the way that knowledge is used and transferred rather than the influence of focusing on the outcomes. It would be interesting to probe into how information and knowledge is transferred within the organization and the how the dynamic interactions of people and processes affect outcomes.

Hypothesis: Individual work effort is driven to a greater extent by compensation when compared to objectives.

The hypothesis can be tested using a model of the response, Y (Work Effort) = X1 (Objectives) + X2 (Compensation) + error (Individual Personality and Work Ethic, other).

Prior to modeling, the difference in the group means of individual's reported work effort when was compared to objectives and compensation. Figure 4.19 provides a

Figure 4.19 One-way Analysis of % Work Effort Profitability By %Objectives Profitability



sample showing a one-way analysis of the percentage of work effort spent on profitability by the percentage of objectives focused on profitability. The analysis shows that the differences are insignificant. Furthermore, the analysis shows that the collective effort of each group is consistent with the group mean. These data can then be used to model the response, Y (Work Effort) = X1 (Objectives) + X2 (Compensation) + error, and test the hypothesis.

When focusing on the senior leaders and managers of the programs, the data show that there is even stronger correlation of those individuals when compared to the entire population of respondents. Table 4.4 shows a comparison of the breakdown of work effort, objectives and compensation by the total population and the management team.

Table 4.4 Model Results of Work Effort by Objectives and Compensation

		Population		Management	
		Rsquare	Prob>F	Rsquare	Prob>F
Work Effort by Objectives	People Development	0.485	<.0001	0.771	0.0004
	Process Implementation	0.616	0.0002	0.914	<.0001
	Cost Reductions	0.841	<.0001	0.719	0.0046
	Profitability	0.832	<.0001	0.992	<.0001
	Customer Satisfaction	0.821	<.0001	0.969	0.0095
Work Effort by Compensation	People Development	0.213	0.0101	0.794	0.0002
	Process Implementation	0.943	<.0001	0.916	0.0001
	Cost Reductions	0.928	<.0001	0.944	<.0001
	Profitability	0.806	<.0001	0.935	0.0002
	Customer Satisfaction	0.543	0.0019	0.421	0.506

The hypothesis of work effort as a function of objectives plus compensation [Y (Work Effort) = X1 (Objectives) + X2 (Compensation) + error] did not hold true in the entire sense when looking at individuals. The traditional metrics of process implementation and cost reduction showed that compensation drove work effort. For the newer, value stream metrics of people development, profitability and customer satisfaction, work effort was more strongly driven by objectives. Table 4.5 shows the results of the model Y (Work Effort) = X1 (Objectives) + X2 (Compensation) + error.

Table 4.5 Model Y = f (X1, X2) Results

Y (Work Effort)	Rsquare	Prob>F	X1 (Objectives)	X2 (Compensation)
People Development	0.396	<.0001	81%	5%
Process Implementation	0.890	<.0001	0%	86%
Cost Reductions	0.883	<.0001	7%	83%
Profitability	0.681	<.0001	64%	22%
Customer Satisfaction	0.527	<.0001	60%	20%

This suggests that the cultural influences established around process and cost reduction still prevail in the method and manner that performance objectives and compensation are established. These data also suggest that the impact of the emphasis on shareholder value and customer satisfaction has migrated to individual objectives. However, people development is a relatively low focus for the organization.

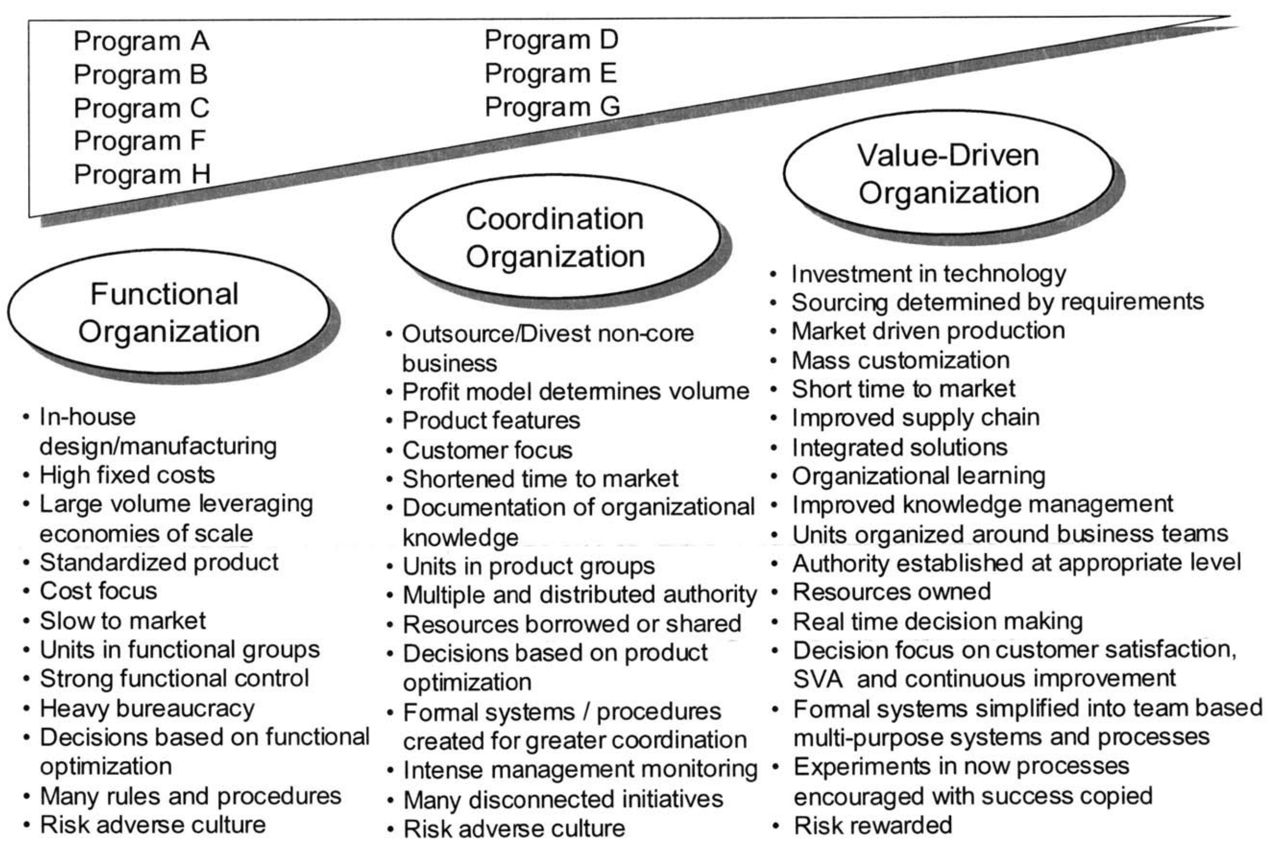
If the hypothesis is looked at by team effort, in general, the trends suggest that team work effort is driven to a greater extent by compensation as compared to objectives. This finding suggests that team compensation in addition to individual compensation may have an influence on outcomes.

Although metrics can be used to align people, product and process, these data also suggest that poorly developed metrics may point people away from the organization's goals and miss critical factors that drive behavior. It is difficult to develop metrics that can accurately assess individual behavior, communication, motivation and other types of personal conduct. The incentive system that links objectives and compensation must be developed to maximize the organizational effectiveness in achieving outcomes and at the same time tie the individual reward system directly to the behaviors that support the goals.

4.3.6 Program Classification within Organizational Model

The Programs were classified using the attributes described in the Organizational Model. None of the program met the criteria of the Value Driven Organization. While many of the Programs shared attributes across categories, Programs A, B, C, F and H had attributes that fell predominately within the Functional Organization. Programs D, E and G had attributes that were more closely associated with those of the Coordination Organization. The overall goal is to drive organizational behavior toward the attributes defined in the Value Driven Organization. Developing a set of transformational performance metrics can do this and their use can focus the work effort and drive the culture of the organization.

Figure 4.20 Program Classification within Organizational Model



5 Conclusions and Recommendations

Performance metrics is a system that measures progress to objectives. They communicate achievements to management and facilitate cross-organization communication in order to enable timely decision-making. It can be concluded that:

1) Teams comprised of skilled people that adhere to processes are successful.
2) Metrics are a means to drive strategic organizational goals.
3) Metrics provide cross organization communication that aid in sound decision-making.
4) Only a select set of high leverage metrics are required to achieve successful outcomes.
5) Incentives (pay for performance) linked to objectives can drive behavior.

5.1 Factors that contribute to successful programs

There were many factors learned from analyzing team and individual performance that can be attributed to successful programs. These factors that contribute to successful programs include functional and process knowledge and understanding, process discipline, appropriate use of metrics, relationship building and aligned objectives and incentives. Programs can apply these factors to improve the overall results.

5.1.1 Common/Shared Vision

Companies as well as teams must have a clear vision of what it is that they are striving to achieve. Ford Motor Company's vision is to be the *world's leading consumer company of automotive products and services.* A shared vision is also necessary for teams to reach their desired goals and achieve superior results. The vision must be compelling and bind people together with a common understanding of who, what, where, when, why and how.

I find the great thing in this world is not so much where we stand, as in what direction we are moving – Oliver Wendell Holmes

A shared picture of the future that motivates and drives people in the same direction is very powerful and leads to successful results. Teams that created a clear common vision, established objectives and documented the progress to those objectives produced better results. Performance metrics can help define the vision and establish common goals for the organization.

5.1.2 Team and Individual Knowledge and Understanding

The high performance teams, Program D, E and G, spent time on training and defining work roles and responsibilities. Early and thorough training of the team is critical to ensure that the team not only understands the deliverables but also their roles and responsibilities and how they fit in the process and contribute to the overall goals. Training on the process and the system effects inherent in a large-scale development program helps individuals understand how their job fits within the bigger picture and how their work affects the work of others. Training should emphasize the system effects of meeting deliverables and the results of delays. Team workshops can facilitate common team learning and understanding of the vision and strategic goals and at the same time develop the set of metrics that the team will use to drive the process. A common understanding of deliverables and program timing is necessary to managing the work with in the system.

Skilled resources that have personal mastery in their specific area of functional expertise as well as an understanding of organizational interactions and process dynamics are imperative to achieving the team's objectives. After establishing a clear vision and understanding of the team objectives, individual objectives must be tied to the overall goals and deliverables. Clear roles and responsibilities ensure that each person on the team knows what he/she should be working on, why it is important to the outcome and how the task fits within the process. Defining the output can be achieved by well-defined tasks and metrics that are tied to those tasks. Clear roles and responsibilities that are tied to performance metrics help streamline the process and minimize confusion when there is a disruption in the process.

5.1.3 Effective Communication

Effective communication involves sharing of key information. Co-location and relationship building are the foundation for efficient communication. In addition to these fundamental building blocks, other standardized and innovative methods can be incorporated to provide additional ways to ensure good communication flow.

Regularly scheduled meetings with stated objectives should be used to effectively communicate with team members. These meetings, which incorporate specific objectives and metrics, can ensure that all team members know the current status to objective and what are the high priority tasks on which to focus their effort as well as which deliverables are forthcoming.

Off-sites can be used in planning, training, and communicating information in addition to further establishing a rapport with entire the team. Offsites can also be used to effectively bring together extended team members to ensure early and ongoing involvement of key individuals in the areas of manufacturing and assembly, marketing, sales and service when these individuals are not permanently co-located with the rest of the team.

Streamlining the types of communication modes can improve team effectiveness. Utilizing the Lean Executive Review Process allows team members to focus on critical tasks rather than spending time preparing for program reviews. Selecting key documents such as the Product Description Letter and Program Parts List to consistently communicate to the team and regularly issuing these documents was shown to have value. In short, establishing the right set of performance metrics can be highly effective in driving results and communicating to the program.

Many teams utilized innovative methods of communication. Pictel facilities were set up to ensure that there was effective communication with all team members; Pictel was especially effective when team members were in locations that prohibited individuals from attending onsite meetings. Web based systems can be leveraged to provide a single medium for team communications. Cell phones and other wireless devices can enable team members to make rapid contact with key individuals to enable quick decision-making. These methods of communication help to increase the flow of information.

5.1.4 Building Relationships

Several of the teams attributed success to establishing relationships among team members. By establishing a cross-functional co-located team, a shared vision for the product can be established as well as to promote effective communications. Co-location encourages the development of relationships among team members. These relationships and personal interactions can help break down barriers that exist across organizational lines and with suppliers and can also enrich communication. Strong interpersonal relationships help develop teamwork. When programs have cross-functional members who consider themselves part of a team, the work effort is focused on achieving the team's goals and can reduce the amount of internal competition and bureaucratic infighting and focus work effort. As Program D said, "co-location led to a cohesive rapport within the team where individuals are embracing common objectives. Team co-location concept worked will – improved communication, facilitated rapid identification and resolution of issues and fostered team atmosphere."

5.1.5 Leadership

Ford Motor Company is transforming its culture to encourage individuals at all levels to be leaders within the organization.

One would argue that the only thing of real importance that leaders do is create and manage culture and that the unique talent of leaders is their ability to understand and work with culture – Edgar Schein

Creating a culture that promotes open communication and good-working relationships is critical to the success of teams. Establishing an environment and culture where risk taking is encouraged and decision-making takes place at the lowest level possible is the goal for the organization. How to accomplish this is by having clear vision, well-defined goals, effective communication, a method of accomplishing the goals and skilled, motivated people.

Good Leadership consists of showing average people how to do the work of superior people – John D. Rockefeller

The job of a leader is to bring expectations of all stakeholders into alignment, to create trust among all parties, to minimize conflict so that everyone is focused on accomplishing their objectives and to allow each person perform to his/her fullest potential. The method of accomplishing the organizational goals is through leadership that enables process adherence and strategic, transformational metrics that the team uses to communicate achievements to management and facilitate cross-organization communication.

5.1.6 Incentives Linked to Objectives

Performance is measured by metrics. Typically, organizations link incentives to performance. For all stakeholders to achieve successful outcomes, three levels of incentives should be established linking performance to outcomes. This incentive structure would include rewarding performance of achieving individual, team and corporate goals.

Because individuals strive to maximize their rewards, they focus on achieving performance to metrics. Individual work effort was found to be primarily a function of objectives plus compensation. An analysis of performance to traditional metrics showed that work effort was linked more closely to compensation than to objectives. It is believed that the newer, value stream metrics must be driven by incentives to drive behavior to achieve the desired corporate goals and culture.

The pay-for-performance system that establishes a base salary with an added increase for additional productivity and effort establishes a competitive relationship among individuals that work on the team when there is a limited budget. Because an individual's work effort is compared to that of his or her team member, caution needs to be taken to ensure that individuals do not end up competing with one another in non-productive ways that cause a economic loss to the firm. One way to do this is to link incentives to team performance.

Teams are formed when complex, interrelated tasks are required and when no one person can have the expertise or the time to complete a sequence of tasks that a team can complete with relative ease. The goal of a successful team is to produce an outcome in a cost-effective manner – to maximize the collective potential through cooperation and teamwork. When people on teams work together toward the same goal they will achieve it more successfully than teams that have individuals working toward different purposes. Individual objectives should be linked to team objectives so that each person is rewarded by his/her contribution to the team goals. Incentives must also be linked to team performance. One way that might be considered is to reward teams according to their outcomes relative to other teams in terms of an added bonus. This type of competition could maximize the outcome of the firm and encourage teamwork and achieving team goals. This type of system would, however, need to consider the cost of monitoring and implementing a team-based incentive system and structure. Team compensation in addition to individual compensation may have an influence on achieving more successful outcomes and driving the strategic goals of the corporation.

Finally, metrics influence the organization's core strengths in producing what it measures. The current system of profit sharing links incentives to the performance of specific metrics that relate to the needs of the firm. By maintaining a profit sharing system that is tied to the outcome of the organization, the organization can utilize metrics strategically to drive behavior and the results of the firm.

5.1.7 Process Adherence

Team discipline and process adherence leads to greater program stability and the ability of the program to meet timing. Early planning, as well as establishing the program deliverables and timing, creates a common understanding of the work that is required by the team. A comprehensive work plan should be created and understood by the entire team. Program E said that a "through construction of a detailed vehicle program plan and customization of the

QOS and team specific deliverables for each FPDS milestone, the program was able to achieve their timing". In addition to focused work effort, a structured process led to more successful outcomes.

5.1.8 Reusability

Reusability is the optimum reuse of common and carryover parts, tooling, facilities, design concepts, and processes (e.g. platforms, architecture, material handling equipment, knowledge, etc.). Reusability provides for resource efficiency as well as complexity reduction and reduced time to market. The notion of reusability can be applied to corporate best practices to leverage proven efficiencies in the methods developed by other programs. Adoption of a reusability strategy aids in achieving program targets by focusing engineering changes only on those systems requiring work effort to support the corporate initiatives.

5.1.9 Appropriate Use of Metrics

The appropriate use of metrics is critical to achieving successful outcomes. Metrics must be linked to strategic goals and team objectives. Teams are confused when there are too many dissimilar metrics. Metrics must be aligned. They should be used to prioritize and focus work as well as support decision-making. They should also be used to communicate the status and document results. The strategic use of transformational metrics can guide the team and eliminate extraneous non-value-added work.

In order for management to assess programs, a common set of performance metrics is required. It was found that only those data used for management reporting and specifically tailored to be easily comparable were common among programs. Also, all comparable data were used to communicate the status of the program and progress to interfacing organizations. Templates are recommended to ensure that the high-level performance metrics can be used strategically to monitor and assess progress of programs and to enable sound decision-making.

Greater influence on outcomes revolves around the organization's focus on the people and the process and the way that knowledge is used and transferred rather than the influence on focusing on outcomes. When analyzing the team performance, the programs that had a higher emphasis on process implementation had better results, suggesting that focus on process implementation has high leverage on outcomes. Teams that balanced their work effort among process implementation, customer satisfaction and financial control, ~ 30%

effort, while spending the remaining 10% on people development were most successful. It is hypothesized that a greater emphasis on people development in terms of personal expertise and work effort would further improve effectiveness and results.

5.2 Strengths and weaknesses of the current process

The strength of the current process is that individuals in Ford have identified specific areas which, when achieved, contribute to successful outcomes. The weakness, however, is in the organization's ability to consistently achieve the goals and implement the process.

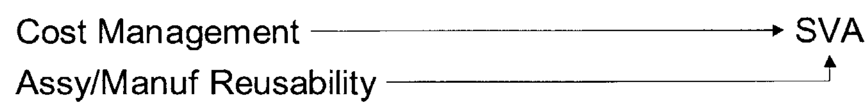
In general, the Health Chart Metrics, the performance metrics that are used for management reviews, provide good correlation with outcomes of timing, shareholder value and customer satisfaction. These metrics provide a balance among factors that relate to the needs of the company and the customer. The only criticism of the current system is that teams are asked to project outcomes. Performance metrics are most effective when they are used to measure factors that can be influenced by the program, not to predict outcomes. Moreover, teams that spend time developing tailored, program-specific metrics were more success than the teams that did not. The Health Chart Metrics provide a good process to communicate status and progress to objectives.

5.2.1 Cost Management

The current cost management process very successful influencing the outcome of Shareholder Value. The strong financial culture that was established with the Whiz Kids is still prevalent in the organization. Ford 2000 did not impact the strong functional division of finance. Therefore, during the reorganization, the process and methods were not as strongly affected as those in the product development areas. The process by which programs manage their fixed and variable costs has been adapted over the years and integrated into the various product development processes that were developed. The process and metrics used have evolved and are considered strengths.

Assembly and manufacturing reusability also has a positive effect on shareholder value. Large investment costs are associated with manufacturing and assembly equipment and facilities. Programs that strongly leverage existing manufacturing and assembly equipment and facilities can directly lower their fixed costs and positively effect shareholder value. One way the corporation has influenced the Product Development Process and lowered costs is through a comprehensive platform and system architecture strategy. Specific strategies have been developed to focus the team's effort and reduce expenditures through implementation of the platform strategy and associated architecture.

Figure 5.1 Effects on Shareholder Value

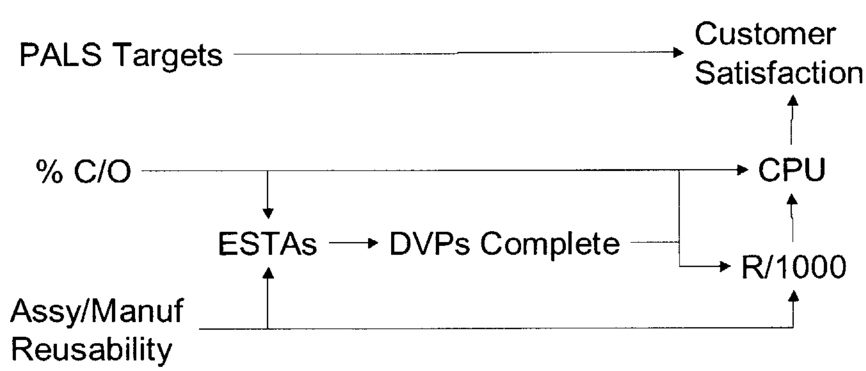


Assembly and manufacturing reusability influence fixed costs. The existing financial process that manages the variable and fixed costs provides an efficient means for the organization to realize greater returns and shareholder value. The organization can realize additional value by leveraging the strategies for platform reusability and system architecture as well as continuing to use the existing cost management processes (Figure 5.1).

5.2.2 Customer Satisfaction

Figure 5.2 shows the various metrics that effect customer satisfaction.

Figure 5.2 Effects on Customer Satisfaction



Although many factors that influence customer satisfaction are outside the control of the product development team, one factor that is critical to achieving high customer satisfaction is having a good understanding the customer and market. Best practices for understanding the customer and setting engineering targets include market research (focus groups, surveys, and immersions clinics), Quality Functional Deployment (QFD) and competitive benchmarking. Programs that had a strong sense of the customer and achieved the attribute targets were successful.

A systems engineering approach to target setting is recommended. This process is based upon best practice techniques for setting system, subsystem and component targets that are associated with the systems engineering "V". Robustness and reliability methods are more appropriate means of assessing product improvements and achieving high levels of customer satisfaction than are the conventional projection techniques. By designing improvements that make the design insensitive to noise and by improving measurements such as mean time to failure, programs can quantitatively assess the product development improvements and assess whether the vehicle can achieve its attribute targets.

Testing and measuring improvements can be done through hardware testing or analytical tools such as CAE. It was demonstrated by the model that robustness methods and CAE Tools have high leverage on customer satisfaction. Also program testimonials suggested that CAE not only has utility for improving customer satisfaction, but also for reducing costs associated with prototypes and testing.

Both warranty measures of cost per unit and repairs per thousand had a strong correlation to customer satisfaction. These outcomes were in turn strongly correlated with manufacturing and assembly reusability and the percentage of carryover parts. As the programs are able to reuse manufacturing and assembly facilities and parts, the complexity associated with the design and development of the vehicle is reduced and results in less warranty costs and repairs. Also, manufacturing and assembly reusability and the percentage of carryover parts were strongly correlated with Early Sourcing Target Agreements (ESTAs). It follows that the greater the number of reusable parts, the fewer number of ESTAs that must be signed.

Early Sourcing Target Agreements were highly correlated with the completion of verification tests. Teams that developed Statements of Work and secured contracts with suppliers using Early Sourcing Target Agreements had higher customer satisfaction. ESTAs provide a means of planning and communicating the goals and requirements of the program to suppliers. Programs can enhance their performance through ESTAs.

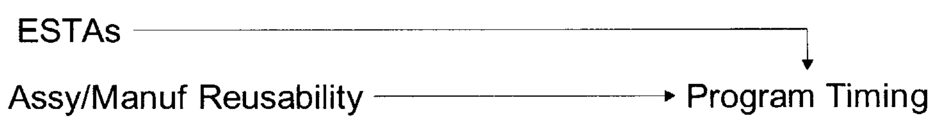
Warranty and successful completion of Design Verification Tests were highly correlated. On-time testing led to lower R/1000 and warranty costs. These lower incidences resulted in improved customer satisfaction.

It is interesting to note that completion of Design Verification Tests was inversely correlated with achieving Targets. It appeared that programs that were more successful in achieving their specified attribute targets were less successful in completing their Design Verification testing on time. This could be attributed to the program spending more time engineering and verifying the design to ensure that the targets were met at the expense of the DV timing. A systems dynamic model of the effects of these factors would potentially indicate whether the reduction in warranty or the functional attributes had a higher influence on customer satisfaction.

5.2.3 Timing

Program timing was highly correlated with ESTAs and Assembly and Manufacturing Reusability as shown in Figure 5.3. As stated before the leveraging assembly and manufacturing facilities and equipment shortens the Product Development Cycle Time. Developing ESTAs provide for a contract that not only drives the functional requirements but also sets expectations for the processes and timing associated with the functional prove out of the product.

Figure 5.3 Effects on Program Timing



5.2.4 Organizational and Process Stability

Programs that did not have stable organization structure and process stability did not perform as well as those teams that were able to minimize the impact of changes to the product development environment. Programs struggle with the impact of the Ford 2000 reorganization that shifted areas of responsibility and resulted in confusion around roles and responsibilities. The new process associated with FPDS caused disruption to the flow of work. Changes to the cycle plan adversely affected ability of programs to meet their timing. Changes to the program assumptions and budgets caused either a stalling of the program momentum or rework for the teams and resulted in late changes to the design. It appeared that teams that had a more stable process were able to remain on track, minimize late changes and produce better outcomes.

During restructuring of the organization, care should be taken to not disrupt the product development process. A plan should be developed that not only defines the positions held by people within the organization, but also their roles and responsibilities. By ensuring that key people remain in leadership positions, the effect of change can be minimized. Logistical planning and facilities are required to ensure a smooth transition.

New processes and their implementation should not coincide with organizational restructuring. Not only must individuals understand their roles and responsibilities but also understand how to get their jobs done. Strong relationships and networks can help the organization overcome difficulties with process implementation. Therefore, separating large-scale reorganization and new process implementation should be avoided when possible.

Successful process implementation occurred when the new process was piloted as a small - scale improvement before being implemented across the organization. Resident experts and program specific training helped teams understand and implement new processes. These methods should be considered as organizational best practices.

5.2.5 Staffing Process

The staffing process was one of the greatest weaknesses. Within the current system, staffing was difficult due to the lack of a robust resource management process.

Investigation into systems that that are used for resource budgeting and tracking found that the data could not be retrieved by program. Therefore, there was no record of how the actual staffing occurred or what level of skill was provided. What was learned is that Programs were given a budget based on the output of the Resource Management System, but few programs stated that they consistently tracked the ramp up process.

Individual responses to the survey suggested that resources were received after they were needed or the team did not receive all the resources that were needed. Inherent in the process is a lag time that occurs between when the resources are approved to work on the team and when the team is able to identify and hire the resources. This lag must be considered when managing resources.

Also, many individuals stated that they did not receive resources with the correct skills. Resources are classified by title and classifications all treated as equal. This method does not ensure that the correct skill level of an individual meets the needs of the program.

Other considerations that must be considered include the appropriate staffing for new process and technology development. The current system assumes that all processes that the team used were fully developed and that the technology was implementation ready. During the phase in of the Ford Product Development System, many team were required to develop processes when implementing new systems. Similarly, programs that chose to be first to incorporate new technologies spent considerable time developing the technologies and associated tests. The resource model did not factor in the additional resources required for development.

In conclusion, a system should be developed that measures the actual staffing to plan and ensures that resources have the right skills to perform the tasks.

5.2.6 Co-location and Facilities

Co-location proved to improve communication among team members, build team relationships and facilitate rapid identification and resolution of issues. In general, co-location was said to be very important in fostering teamwork.

The availability of the necessary space and equipment proved to be one difficulty with team co-location. Inadequate planning caused difficulties during rapid resource ramp ups. Programs spent considerable time negotiating for space and equipment that should have been available to the team. The effort that was spent on negotiations detracted from the effort that could have been focused on product development.

Preplanning is required to ensure that co-location benefits can be realized given the limited human resources, workspace and equipment that are available.

5.2.7 Objectives and Compensation

When analyzing work effort as a function of objectives plus compensation it was found that individual work effort was driven more strongly by compensation that objectives. These findings suggested that the cultural influences established around the more traditional metrics of process and cost reduction still prevail in the method and manner that performance objectives and compensation are established. These data also suggested that the impact of the emphasis on shareholder value and customer satisfaction has migrated to individual objectives while people development remained as a relatively low focus for the organization. Strategically developed objective for the individual and team that are linked to compensation can influence the way people perform. The new A, B, C Performance system that links compensation to performance results will reinforce the attributes of a value-driven organization.

The incentive structure can be used to influence work effort and to shape the organization's culture. Aligned objectives that are linked individual, team and corporate goals can focus the organizational effort. Compensation that is based on performance to objectives can influence the level of individual work effort that is expended on achieving objectives.

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6 Recommendations

6.1 What are the optimal combinations of metrics?

The optimal combination of performance metrics for Product Development are those metrics that are highly correlated with the desired outcomes of Customer Satisfaction and Shareholder Value and those metrics that can be used to communicate and drive behavior. Analysis of the eight Product Development Programs have led to the recommendations for the subset of performance metrics shown in Table 6.1.

Table 6.1 Recommended Product Development Peformance Metrics

#	Category	Metric
1	Resources	Resources Commitment vs. Program Requirements
2	Affordable Business Structure	Profitability, Variable and Fixed Cost Status vs. Target
3	Reusability Strategy	Standard, C/O and New Tooled Parts vs. Target
4	Supply Plan	$ Value of Target Agreements Signed vs. Plan
6	Targets	Vehicle Level Targets Not Compatible
7	Technology Strategy	Implementation Ready Technologies Identified vs. Plan
8	Quality and Reliability Plan	DVPs and FMEAs Complete vs. Plan
9	CAE Verification	Targets Verified by CAE
10	PSW	%PSW parts
11	Timing	Milestone Achievement and Timing

6.2 What actions can be implemented to improve the current process?

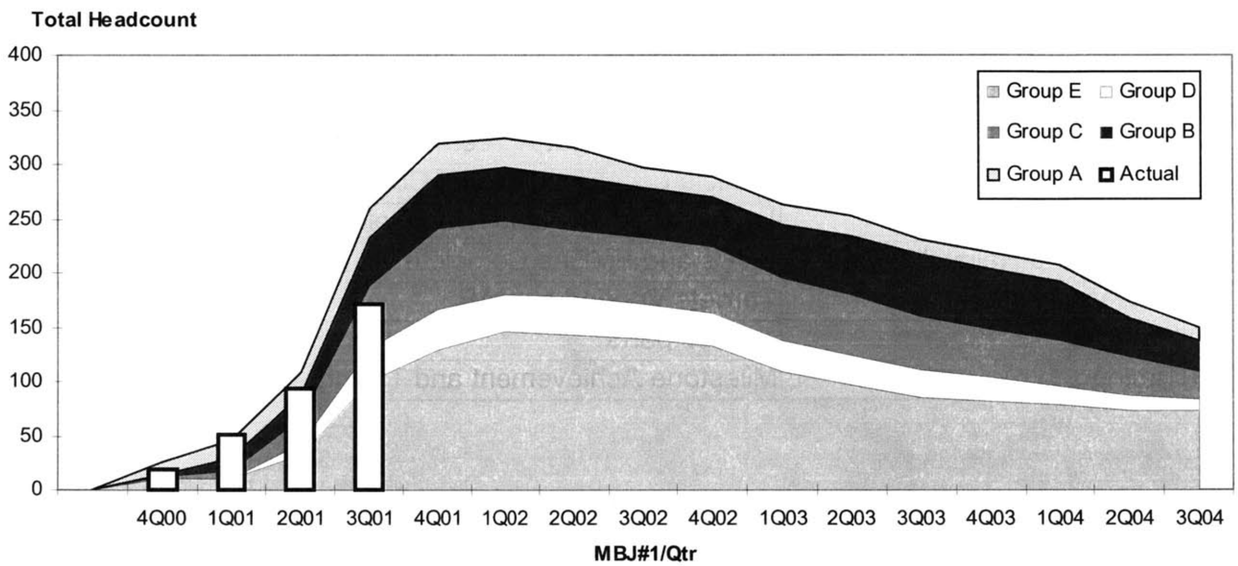
Actions are needed that drive the behavior of the program team and result in alignment of objectives with the organizational goals. One method of achieving the desired results is to develop a set of aligned metrics that can be used to focus the team's effort. The other is to devise an incentive structure that rewards individuals that demonstrate superior performance and appropriate leadership behaviors.

The following performance metrics have been developed to ensure that all necessary requirements have been fulfilled to meet the deliverables and to measure progress to objectives. They should be considered as the common format to communicate achievements to management and facilitate cross-organization communication to enable decision-making.

6.2.1 Resources

The resource metric shown in Figure 6.1 measures the number and type of resources required by the team over time during the Product Development program. The resource plan should be developed at the initiation of the program and based on the design assumptions and budget. The status to plan should be updated quarterly. This metric measures the resource staffing to plan and enables resource discussions and the implications of late or unskilled staffing.

Figure 6.1 Resources Committed vs. Plan



In addition to the headcount, the program must be able to assess the skill level of the resources. A skill assessment matrix can be used in conjunction with the performance metric to evaluate whether the work on the program can be achieved with the actual resources that are staffed on the program.

6.2.2 Affordable Business Structure

The Affordable Business Structure metrics measures the Variable Cost vs. Target (Figure 6.2), Fixed Cost vs. Target (Figure 6.3) and Program Profitability (Figure 6.4). These metrics allow the team to measure the status of the program over time and can be used to communicate to various stakeholders. Specifically, the Variable Cost Metric can be used to convey the program status to the team and supply base; the Fixed Cost Metric provides a means of communication between the program and manufacturing; and, the Profitability Metric make available information that is important to senior management.

Figure 6.2 Variable Cost Status B(W) Target History

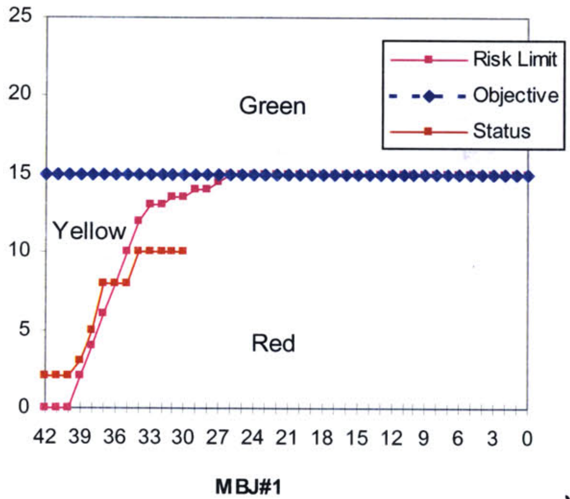
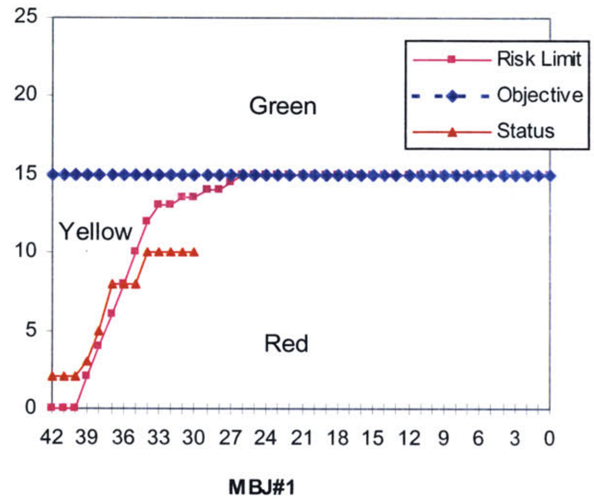


Figure 6.3 Investment Status B(W) Target History



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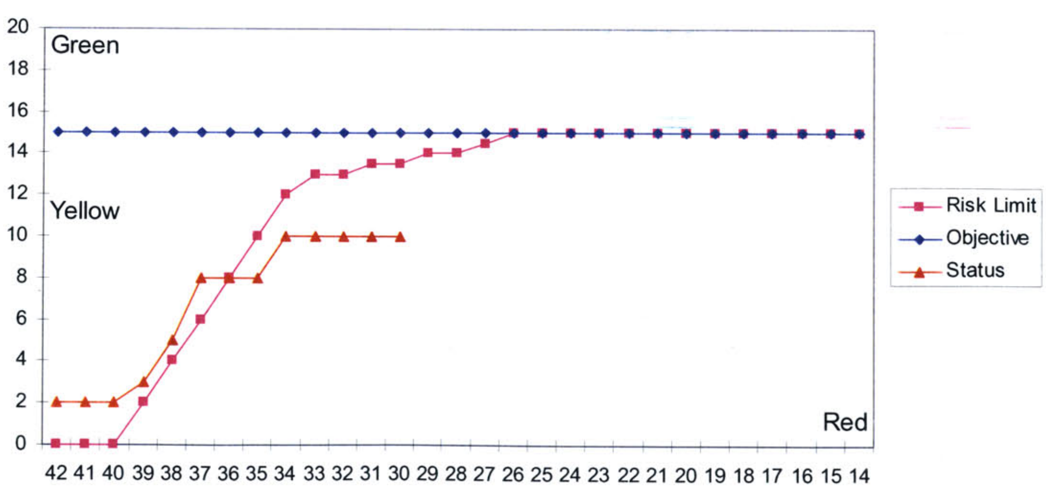


6.2.3 Reusability Strategy

A Program Reusability Strategy defines the optimum reuse of common and carryover parts, tooling, and facilities. This strategy impacts the program investment efficiency and timing. Two metrics can be utilized to communicate the team's plan and status. Figure 6.5 shows the metric of Standard, Carryover, New Parts vs. Plan. The metric of Plant Reusability vs. Plan, Figure 6.6, can be used to communicate the status of the program to the team and manufacturing.

Figure 6.5 Standard, Carryover, New Parts vs. Plan

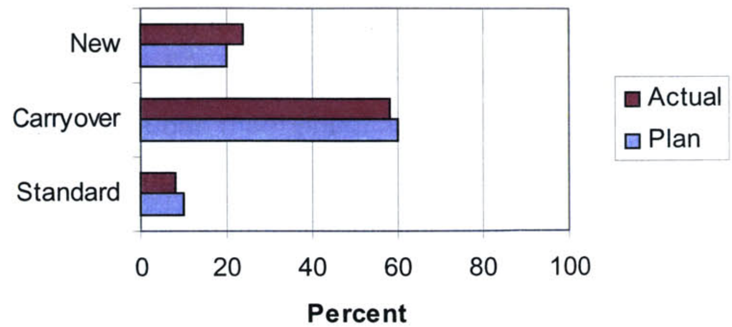
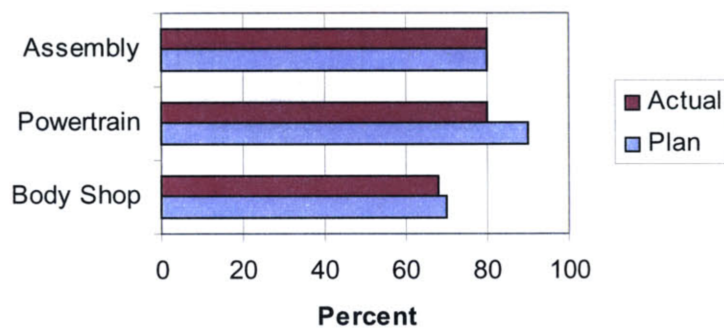


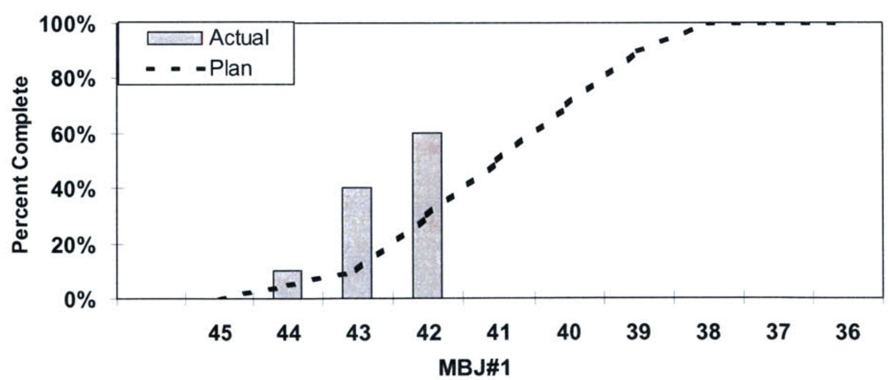
Figure 6.6 Plant Reusability vs. Plan



6.2.4 Technology Strategy

This metric reports on the program technology application status. It conveys the success of the team to incorporation the specified number of implementation ready technologies into the vehicle design based on the program's technology strategy (Figure 6.7).

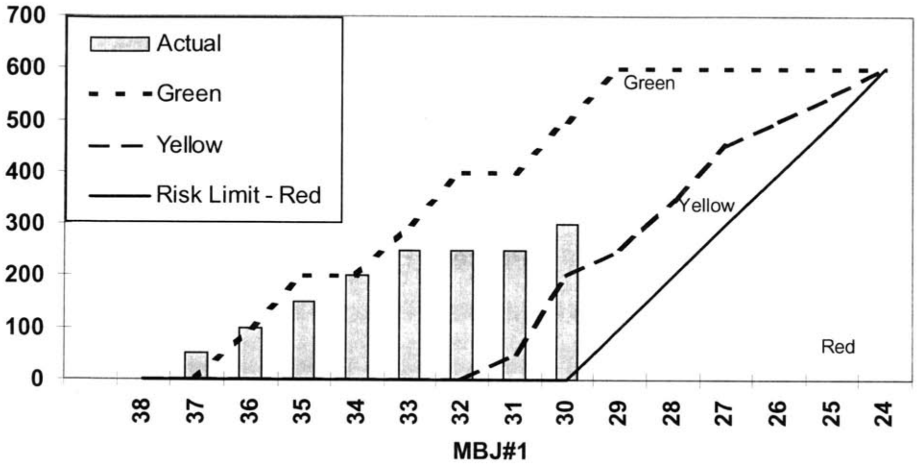
Figure 6.7 Technology Implementation vs. Plan



6.2.5 Supply Plan

Target Agreements Signed vs. Plan signifies the number of suppliers onboard with completed Statements of Work defining the program requirements (Figure 6.8). ESTAs have a strong impact on the outcomes of timing and completion of testing and verification.

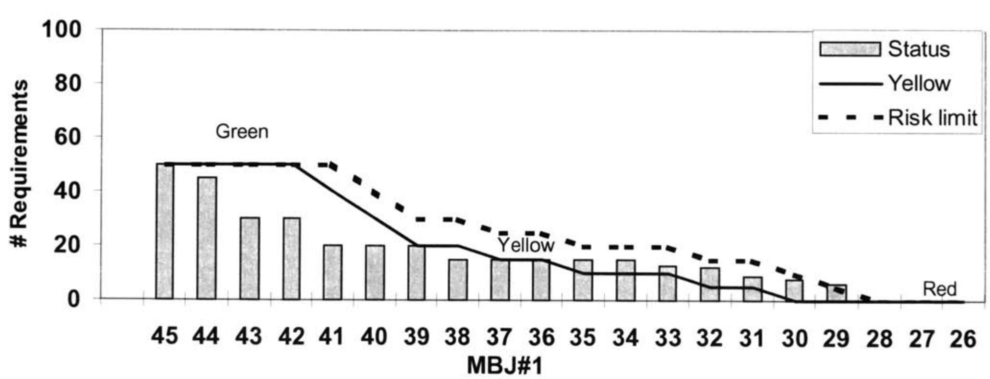
Figure 6.8 Target Agreements Signed vs. Plan



6.2.6 Targets

As described in the Systems Engineering "V " Model, during the product definition period, the team must identify the customer needs and translate these assumptions into product engineering targets and requirements through an iterative process moving from vehicle level assumptions and targets to compatible system, subsystem and component targets. The performance metric that measures the number of targets not compatible with assumptions can be used to evaluate progress (Figure 6.9). These targets encompass the vehicle, system and component level targets that must be established prior to product design.

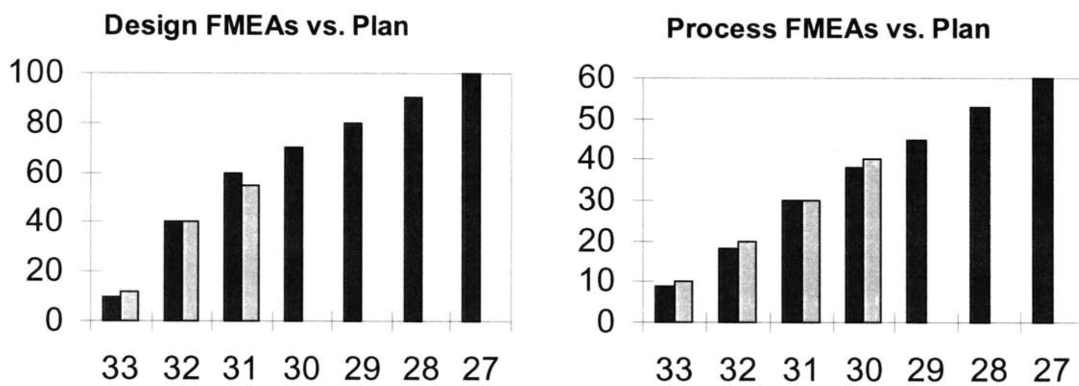
Figure 6.9 Targets Not Compatible with Program Assumptions



6.2.7 Quality and Reliability Plan

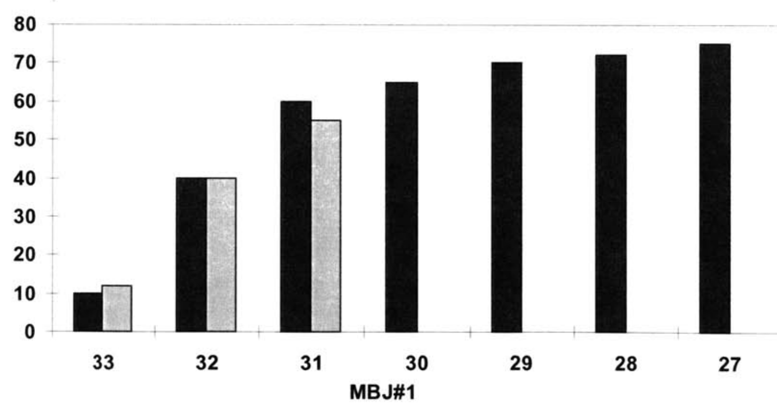
The Quality and Reliability Plan is developed to ensure that the end result of the Product Development Process meets the customer's expectations in the area performance, reliability and durability. One a process that is used to ensure that all failure modes are identified is Failure Mode Effects and Analysis. FMEA activities not only ensure that the team recognizes and evaluates potential failure modes of products and the effects, but also identifies actions to eliminate or reduce the chance of the potential failure occurring. Figure 6.10 shows the metric of Design and Process FMEAs Completed vs. Plan.

Figure 6.10 Design and Process FMEAs Completed Vs. Plan



After the team defines the targets and designs the parts the analysis phase begins. The right hand side of the System Engineering "V" represents the serial confirmation process that verifies each level from the lowest level component through the complete vehicle. Once all of the elements of the product are verified, product validation begins. Product validation includes the testing and certification of parts before production Job #1. A comprehensive testing plan is required to ensure that all parts meet the requirements. The metric that measures the Component, Sub-System, System and Vehicle Design Verification/Product Validation Tests

Figure 6.11 Design Verification/Product Validation TEsts vs. Plan

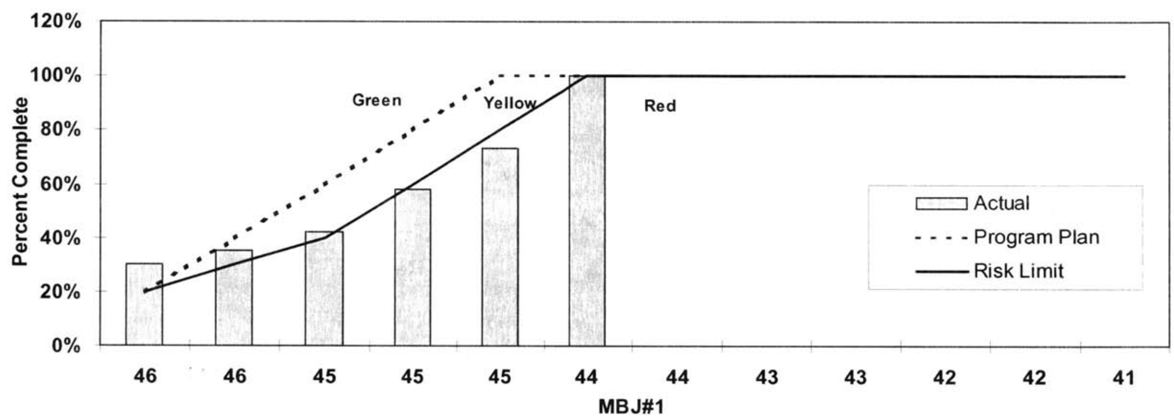


vs. Plan (Figure 6.11) can be used to ensure that the quality and reliability goal of the product are met.

6.2.8 CAE Verification

The metric of Targets Verified by CAE vs. Plan, Figure 6.12, defines the success in using analytical tools to verify the vehicle, system and component targets prior to validation. It can be used in conjunction with the Design Verification Plan to ensure that functional targets are met. The use of analytical tools and methods affect Customer Satisfaction and can improve the Affordable Business Structure.

Figure 6.12 Targets Verified by CAE vs. Plan



6.2.9 PSW

Leading up to the final validation of parts, Percentage of Parts Released vs. Plan (Figure 6.13) can be used as an early indicator to predict the likelihood of the team's success in receiving all of the Parts Submission Warrants on time. Before production, all of the parts must be validated by PSWs before the vehicle is signed off for production. The Release Metric in conjunction with the metric Number of Parts with PSW vs. Plan (Figure 6.14) can be used to gauge and communicate the program's status.

Figure 6.13 Percentage of Parts Released vs. Plan

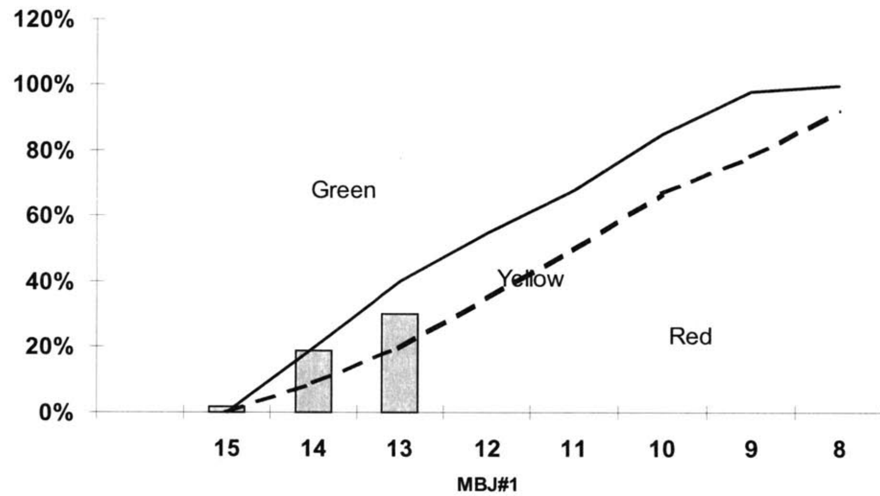
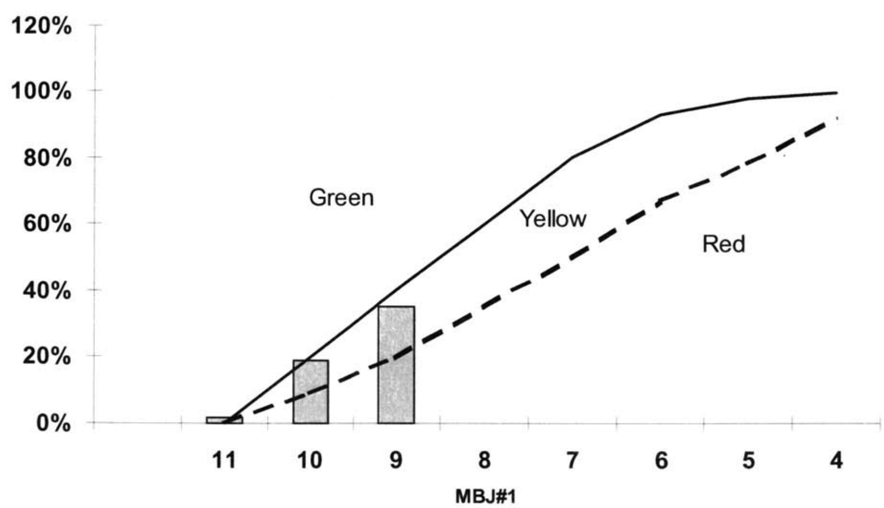


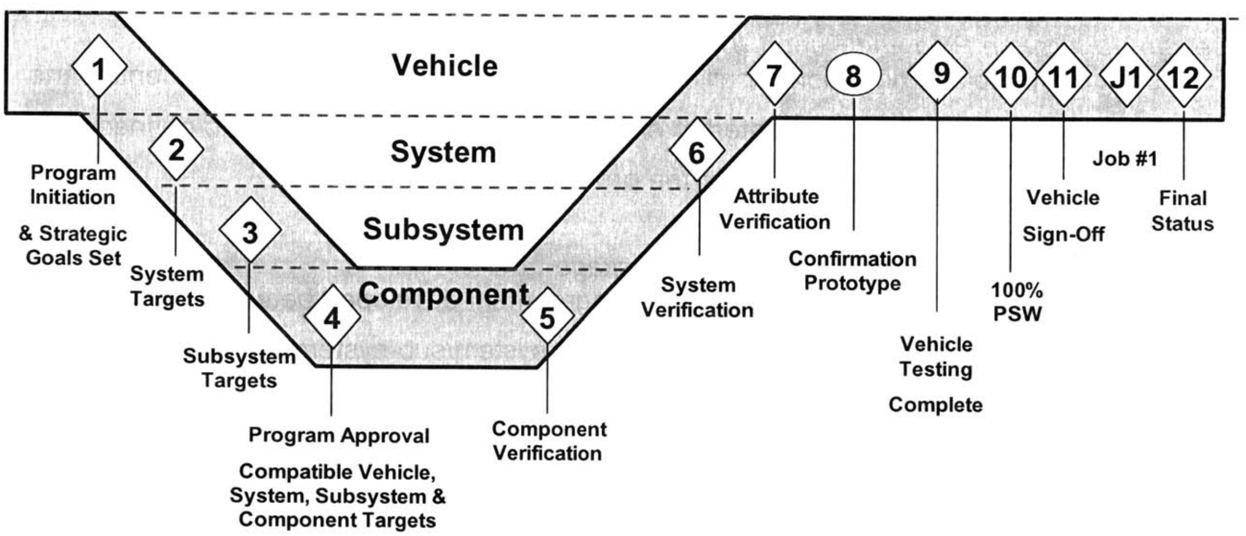
Figure 6.14 Percentage of Parts with PSW vs. Plan



6.2.10 Timing

An overall timing plan must be established and monitored to ensure that the program and other stakeholders know when tasks and deliverables must be completed. A high level plan can be established to communicate the team's plan (Figure 6.16). Lower level, tasks and their associated deliverables and establish the plan and timeline. Programs exist that are tailored to assist in project management can be used to develop these work plans.

Figure 6.15 Timing Plan



6.2.11 Organizational Dynamics Survey

Finally, an organizational dynamics survey can be developed to measure the social factors that contribute to successful programs. These factors include how individuals assess team leadership, decision-making, knowledge transfer and development, communication effectiveness, process efficiency, individual development and overall employee satisfaction. Periodic measurements of the social factors can be used to gauge the organization's knowledge capacity and growth. The results of these measurements can then be used in conjunction with the results of the more technical measures to identify what sets of behavior affect the outcomes and further the goals of the organization.

Definitions

Advanced Product Quality Planning (APQP)
APQP is a standardized process and communication method used in product development by OEMs and suppliers. APQP was developed and is utilized by Ford, Chrysler and GM as the common method of demonstrating that a product meets design intention and customer needs

Affordable Business Structure (ABS)
Profitability measured as return on sales vs. program objectives.

Design Verification Plan and Report (DVP&R)
This is the testing plan and report for all vehicle, system, subsystem and components parts that are subjected to tests. It is created to ensure that the designs conform to defined user needs and engineering requirements for the product.

Early Sourcing Target Agreement (ESTA) Package
Signed Early Sourcing Target Agreement is an agreement developed between the OEM and supplier containing a completed statement of work, system/sub-system design specification, and detailed work plan.

Failure Mode Effects Analysis (FMEA)
FMEA is an analytical technique that uses the potential failure modes of the design of a system (System Design FMEA), product (Product Design FMEA) or process (Process FMEA) and the causes to prioritize improvement opportunities. The FMEA should be treated as a living document that is updated as necessary whenever the process changes.

Ford Reliability Guide (FRG)
The FRG is a guide that is based common concepts and methods and focused on producing reliable vehicles, systems and components. Reliability techniques and disciplines are integrated into systems approach for product planning, design, development, manufacturing, supply, delivery, and service. The concepts include define requirements, design for robustness and verify design.

Parts Submission Warrant (PSW)
The Parts Part Submission Warrant is a report of the test results of the initial production sample. Initial samples must be produced from production tooling and process during a run

of at least 300 units at production rate. These parts are checked for dimensional accuracy and the test performance.

Product Development Process
The product development process consists of four phases: Define, Design, Verify and Manage. Define phase is the process by which a team translates the voice of the customer into engineering specifications, plans the scope, affordable business structure and other required resources. Design Phase is the process of cascading requirements, and carrying out the design of the product and manufacturing processes. Verify Phase is the analytical prove out and hardware verification and certification of the product and processes. Manage Phase consists of life cycle elements such as warranty, service, distribution and production improvements.

Reliability
Reliability is the probability that the product will perform its function over time/mileage under specific operating conditions. It can be defined as the percent of vehicles that meet customer requirements (do not fail) at prescribed time or mileage.

Reliability Demonstration
A reliability demonstration is the process that validates that the reliability targets have been achieved. This includes documentation testing and calculations of B10 life or Mean Time Between Failure (MMBF) or Mean Time To Failure (MTTF).

Specification
A specification is a numerical value or limiting statement that defines functional or physical characteristics of vehicle, system, sub-system, or component.

Statement of Work (SOW)
A document prepared by PMT Engineering that identifies the commodity assumptions, design responsibility, specifications, technical specifications, program objectives/assumptions, and timing of milestones. The Statement of Work is included with the Early Sourcing Targets Agreement Package.

Systems Engineering
A customer-driven engineering and management process which transforms the voice of the customer into a feasible and verifiable product/process of a specified configuration, performance and price.

Systems Engineering "V"
The Systems Engineering "V" is a model used to explicitly explain Systems Engineering. The left hand side of the "V" translates the voice of the customer into specifications that are cascaded from Vehicle to System to Subsystem to Component in an iterative process of checks and balances. The right hand side is a serial confirmation process that verifies that the specifications are met starting with the part level through to the completed.

System (Subsystem) Targets
System (Subsystem) level targets are metrics that define interface requirements between the various systems (subsystems) of the vehicle (system) hierarchy that are necessary to achieve the vehicle (system) level targets. Many of these interface targets will map directly to sub-systems or the individual end-items/components that are the elements that are manufactured by the tier one supplier.

Target Agreement
The contract signed by OEM and Supplier defining acceptance levels for the product. See Early Sourcing Target Agreement (ESTA).

Targets
Sets of reasonable, consistent goals that provide the best combination of product attributes that satisfy the customer, government regulations and corporate requirements.

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Attachment 1: Individual Evaluation and Belief Survey

To: *<NAME>*

I would like to ask for your help. I am in the process of gathering data for a thesis that I am completing at MIT this fall. My thesis is on product development metrics and their impact on product performance. The data that I have collected to date does not cover all aspects of interest.

I need your assistance in the form of a completed survey to accomplish my research and perform the analysis. Your answers to the survey questions will fill in areas where no performance metric data was available from document sources. The output of the thesis will be used to evaluate and potentially establish the performance metrics that Ford will use after the upcoming reorganization.

You were selected because of your responsibility on the <Generic> Program. It will only take a short time to answer the questions on the attached questionnaire. All answers are confidential and will be used only in combination with those of other programs.

Thank you for your help in my effort! I would appreciate your completed questionnaire by November 7, 2000. Please e-mail the completed form to drobison@ford.com.

If you are interested in receiving a copy of my thesis, please let me know.

Sincerely,

Dawn Robison

PROGRAM INFORMATION

Please check your program:

- ☐ PROGRAM A
- ☐ PROGRAM B
- ☐ PROGRAM C
- ☐ PROGRAM D
- ☐ PROGRAM E
- ☐ PROGRAM F
- ☐ PROGRAM G
- ☐ PROGRAM H

Please identify your Program Responsibility:

- ☐ Chief Engineer
- ☐ Functional Manager
- ☐ Staff Manager
- ☐ Functional Supervisor
- ☐ Staff Supervisor
- ☐ Engineer
- ☐ Process Specialist

NOTE: Specific program and personal information will not be shown in the final report to preserve confidentiality.

INSTRUCTIONS

There are 32 questions in the survey. Please think about the following questions in relationship to the recently launched product model on which you worked. Please check only one box unless instructed to do otherwise.

OVERALL PRODUCT

Which of the following would best describe the product?

☐ Breakthrough Product
☐ New Company Platform
☐ Derivative to an Existing Platform
☐ Primarily Carry Over with Minimal Updates to Existing Product

PROGRAM DURATION

Given the scale of the program, please mark the appropriate box (percentage) that would best describe the duration of program.

☐ About Average
☐ Longer than Average by ______%
☐ Shorter than Average by ______%

TECHNOLOGY

Which of the following would best describe the technology used in the design of the product?

☐ Off the Shelf Technology
☐ Proven Technology (requiring minimal changes to implement)
☐ Implementation Ready New Technology (requiring low degree of program development)
☐ Radically New Technology (requiring high degree of program development)

Think about how this technology was received by the customer. On the following scale mark the Market Impact of the Technology.

High				Low
☐	☐	☐	☐	☐

How many hours per week did you spend on technology development? ______hours

MARKET DRIVERS

In thinking about Consumer Needs, to what degree did the program design for stated customer vs. latent customer needs?

Stated Customer Needs				Latent Customer Needs
☐	☐	☐	☐	☐

In thinking about Competitive Products Entering the Segment, where would you categorize the market segment for your program?

New Segment	Many New Entrants	Few New Entrants
☐	☐	☐

How many hours per week did you spend on meeting consumer's needs? ______hours

INTERDEPENDENCE

Task Interdependence describes the number of inputs required to complete tasks. What degree of task interdependence did this program have?

High				Low
☐	☐	☐	☐	☐

Process Interdependence describes the nature of the tasks and the amount of rework required to complete tasks.
When reflecting on this program, select the nature of the majority of task using the following scale:

Highly Iterative ☐ ☐ ☐ ☐ ☐ Sequential

PRODUCT/PROCESS KNOWLEDGE
To what degree was the program based on new technology compared to old technology?

New Technology ☐ ☐ ☐ ☐ ☐ Old Technology

To what degree was the program based on Ford Product Development Process (FPDS) compared to the World Class Process (WCP)?

FPDS ☐ ☐ ☐ ☐ ☐ WCP

RESOURCES
Think about the skill level of the team. Where would you categorize the team knowledge?

Deep Functional Knowledge ☐ ☐ ☐ ☐ ☐ Broad Process Knowledge

How would you classify the resource allocation process?
☐ Received skilled resources on time
☐ Received skilled resources after they were needed
☐ Received resources without the correct skills on time
☐ Received resources without the correct skills after they were needed
☐ Did not receive all the resources that were needed

PROCESS STABILITY
Which of the following would best describe the process used by your team?
☐ Entirely FPDS
☐ Mostly FPDS
☐ Mostly WCP
☐ Entirely WCP

How many hours per week did you spend on process or process development? ______hours

PROCESS DETAIL
Which of the following would best describe the process detail available to your team and the effort required to implement the process?
☐ Available and proven off-the-shelf documentation
Team has tacit knowledge of the process
☐ Some available documentation
Team required documentation and was able to use it effectively on program
☐ Available documentation did not meet needs of program
Some process adaptation required by team
☐ Radically new process with little documentation
Team required to develop process

ORGANIZATIONAL STRUCTURE

In thinking about how the organization of the program was structured, please select from one of the following:

☐ Functional Departments
☐ Attribute Groups
☐ Business Unit

ORGANIZATIONAL FOCUS

In thinking about the focus of the organization's efforts, please check one box for each question:

What percent of the team's effort was focused on Functional Excellence as compared to Customer Needs?

☐ 100% Functional Excellence
☐ 75% Functional Excellence / 25% Customer Needs
☐ 50% Functional Excellence / 50% Customer Needs
☐ 25% Functional Excellence / 75% Customer Needs
☐ 100% Customer Needs

What percent of the team's effort was focused on Functional Excellence as compared to Process Implementation?

☐ 100% Functional Excellence
☐ 75% Functional Excellence / 25% Process Implementation
☐ 50% Functional Excellence / 50% Process Implementation
☐ 25% Functional Excellence / 75% Process Implementation
☐ 100% Process Implementation

What percent of the team's effort was focused on Customer Needs as compared to Process Implementation?

☐ 100% Customer Needs
☐ 75% Customer Needs / 25% Process Implementation
☐ 50% Customer Needs / 50% Process Implementation
☐ 25% Customer Needs / 75% Process Implementation
☐ 100% Process Implementation

TOOLS

What level of effort was placed on use of CAE/CAD tools?

High				Low
☐	☐	☐	☐	☐

What level of effort was focused on robustness (FMEA, parameter design, DOE, tolerance design)?

High				Low
☐	☐	☐	☐	☐

What level of effort was placed on verification of reliability?

High				Low
☐	☐	☐	☐	☐

METRICS

Which Metrics did the team use? Please check all that apply:

- ☐ QOS
- ☐ FPDS
- ☐ PIR
- ☐ Program Health Chart
- ☐ Program Specific Metrics (internally developed and used)
- ☐ Functional Organization Metrics (Manuf, Quality, APQP, other)
- ☐ Other (please specify ________________________________)

Which Metrics added value? Please check all that apply:

- ☐ QOS
- ☐ FPDS
- ☐ PIR
- ☐ Program Health Chart
- ☐ Program Specific Metrics (internally developed and used)
- ☐ Functional Organization Metrics (Manuf, Quality, APQP, other)
- ☐ Other (please specify ________________________________)

Do you feel that the all of the metrics that teams are required to use are aligned?

- ☐ Yes
- ☐ No

Do you feel that teams are required to use to many dissimilar metrics?

- ☐ Yes
- ☐ No

YEARLY OBJECTIVES/COMPENSATION/WORK EFFORT

What percentage of your cascaded objectives were focused on:

People Development		_____%
Process Implementation		_____%
Cost Reductions		_____%
Profitability		_____%
Customer Satisfaction	+	_____%
TOTAL		100%

What percentage of your compensation was based on:

People Development		_____%
Process Implementation		_____%
Cost Reductions		_____%
Profitability		_____%
Customer Satisfaction	+	_____%
TOTAL		100%

What percentage of your day-to-day effort was focused on:

People Development		_____%
Process Implementation		_____%
Cost Reductions		_____%
Profitability		_____%
Customer Satisfaction	+	_____%
TOTAL		100%

Do you feel that these three elements were aligned?

☐ Yes
☐ No

I welcome any comments or thoughts that you have regarding the subject of the questionnaire.

COMMENTS:

Thank you for taking the time to complete this survey

Attachment 2: Alignment of Work Effort, Objectives and Compensation

		Objectives	Compensation	Work Effort
Program A	People Development	0.08	0.15	0.08
	Process Implementation	0.19	0.38	0.31
	Cost Reductions	0.24	0.19	0.19
	Profitability	0.11	0.04	0.05
	Customer Satisfaction	0.38	0.37	0.32
Program B	People Development	0.09	0.04	0.10
	Process Implementation	0.42	0.28	0.42
	Cost Reductions	0.09	0.28	0.09
	Profitability	0.15	0.20	0.17
	Customer Satisfaction	0.23	0.14	0.22
Program C	People Development	0.12	0.08	0.09
	Process Implementation	0.17	0.15	0.10
	Cost Reductions	0.22	0.28	0.22
	Profitability	0.20	0.28	0.33
	Customer Satisfaction	0.30	0.20	0.27
Program D	People Development	0.11	0.04	0.06
	Process Implementation	0.14	0.34	0.41
	Cost Reductions	0.25	0.14	0.10
	Profitability	0.15	0.19	0.10
	Customer Satisfaction	0.35	0.25	0.33
Program E	People Development	0.07	0.05	0.08
	Process Implementation	0.41	0.41	0.47
	Cost Reductions	0.14	0.08	0.09
	Profitability	0.18	0.22	0.18
	Customer Satisfaction	0.21	0.24	0.20
Program F	People Development	0.07	0.06	0.09
	Process Implementation	0.16	0.13	0.21
	Cost Reductions	0.10	0.09	0.08
	Profitability	0.18	0.28	0.12
	Customer Satisfaction	0.49	0.32	0.50
Program G	People Development	0.10	0.07	0.09
	Process Implementation	0.22	0.18	0.30
	Cost Reductions	0.07	0.03	0.03
	Profitability	0.21	0.30	0.15
	Customer Satisfaction	0.41	0.43	0.43
Program H	People Development	0.15	0.12	0.13
	Process Implementation	0.18	0.17	0.16
	Cost Reductions	0.09	0.03	0.08
	Profitability	0.20	0.23	0.13
	Customer Satisfaction	0.34	0.45	0.46

Transformational Metrics for Product Development