Product Development: A case study of General Motors

by

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ABSTRACT

In recent years there has been a great deal of attention given to the importance of manufacturing and manufacturing strategy in both the popular and academic press when analyzing companies. But given that companies need products to manufacture and that manufacturing performance is significantly influenced by the upstream design and development process, it may be the design and development process that will largely dictate the success of companies in the future.

This thesis addresses the design and development process in the automotive industry. It presents an overview of the importance of the design process as well as some general approaches to product design, then presents some current design organizations in the automotive industry. The primary purpose of this thesis is the presentation of a case study involving product design at General Motors, including an examination of the product strategy that led to General Motor's early success and an investigation into it's current product make-up.

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I. INTRODUCTION

A great deal of attention has been spent on the importance and issues involved with the manufacturing arena recently. There has been a great deal of study and discussion regarding the importance of manufacturing, and the competitiveness of American manufacturing firms. Even in the realm of the measurement of productivity, the manufacturing productivity receives a greater portion of attention than does the upstream design aspect of productivity and the influence that this has on the competitiveness of a firm.

One reason that the product development process receives less emphasis lies in the difficulty of measuring a process that's outcome is by nature intended to be secretive. Although it may be difficult to measure the design performance of products currently being designed within a company, the design process of a company can be studied, and must be understood in order to determine the long term productivity of a company. After all, it is the product development and product engineering departments that provide the manufacturing plant with a product to produce.

The notion of lean manufacturing and agile manufacturing have become rallying calls, yet by the time products reach the manufacturing floor, the manufacturing process has to a great extent been fixed by the design. Although there are tremendous gains that can be made through the implementation of Just-In-Time inventories, Andon systems, Kan-Ban systems, etc., the competitiveness of manufacturing firms should be evaluated on the bases of their product development strategy as well as their manufacturing strategy. Firms should be evaluated on the basis of how well they make the trade-off between commonization of parts verses product identity, how well they manage multiple projects, react to the customer needs, and manage communication among the different disciplines of the company. After all, the development process dictates what the manufacturing floor will produce, and the competitiveness of the firm
in the future. Since the current development process in a manufacturing firm largely dictates the future manufacturing efficiency, I would argue that manufacturing efficiency and productivity is a short term measure of a firm's performance, while product development performance is an indicator of the future performance.

Many firms have changed their philosophy with regard to product development strategy in recent years. In fact, the most widely adopted product development strategies seem to come from the same firms that are the most apt at manufacturing. Although the product development strategies are not the same among the most competitive firms, there are particular characteristics that make these firms successful. These characteristics include effective management, organization and empowerment of personnel, effective communication among disciplines at the working level of the firm, and a sound product portfolio.

General Motors has gone through various transformations since its inception, the most drastic since the reorganization of the 1820's by Alfred Sloan occurred in 1984 when Roger Smith combined the various entities that provided product development support for the corporation into two units. Prior to 1984, each of General Motors' five vehicle divisions had engineering design responsibility for their vehicles, Fisher Body had the task of designing the bodies, and GMAD (General Motors Assembly Division) built the vehicles. When Roger Smith reorganized the company in 1984, Fisher Body and GMAD were abolished, and only two engineering units remained - Buick, Oldsmobile, Cadillac group (BOC), and Chevrolet, Pontiac, GM Canada group (CPC). The vice president in charge of each group had the latitude of structuring the organization as they desired. BOC selected a vehicle team approach, while CPC continued the hierarchical matrix organization already used in General Motors.

This thesis presents an overview of the importance of the design process and general approaches to product design. Then this thesis reviews some current design
organizations within the automotive industry, followed by an examination of the early
history of General Motors and the product strategy that led to its success. It also
investigates the make-up of the two vehicle groups created in the 1984 reorganization.
A cursory look is taken at the effectiveness of the team oriented organization pioneered
by the BOC through a comparison of vehicle sales by the two groups.

An insight is presented on how the CPC organization was structured in 1991,
and how it effectively operated. The latest changes reported to be occurring at General
Motors through the creation of a North American Operations Technical Center and the
introduction of a "Vehicle Launch Center" are also presented. This thesis concludes
with perspectives on the function and organization of the product development
organization.
II. GENERAL ISSUES RELATING TO PRODUCT DESIGN

In the design process, there are five general issues that a company must address relating to product design that will effect the competitiveness of a firm. These five issues are: (1) the impact of product design on product costs; (2) the importance of having the correct product for the target market; (3) the strategic importance of a product portfolio; (4) the importance of timing the release of a product onto the market; and (5) the sources of innovation for new product programs. Although there are many more issues involved in a successful business, mastery of these five issues composes the structure that enables the product development process.

Impact of Product Design on Costs

Within the design and development process there are many issues that impact the eventual productivity of a design during manufacturing. There is, however, no stage that has a greater impact on cost than the concept stage. By virtue of the fact that the design process dictates the materials to be used as well as the manufacturing process, over 70% of a product's total life cycle costs can be defined in the concept stage of product design.\(^1\)

With 70% of the cost being determined in the initial concept stage of design, it is critical that the concept stage be done properly, and that decisions be made by individuals who understand the downstream effects of the decisions. An issue that firms must address, is building the knowledge of the designers in the concept stage and providing a mechanism of communication between design engineers and manufacturing engineers. A metric to determine a firm's capability in this area is the rotation and training of personnel in the advanced development area.

\(^1\) Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on road sooner," Automotive News, (22 Feb. 1993), 3
Correct Product for the Market

To paraphrase Maryann Keller of Furman, Selz Inc., customers close factories because they buy someone else's products. Customers buy someone else's products because someone else provides something they want. That's why plants close. This idea underlines the importance of the development process.

Since there is typically a lag between the time a concept is initiated and the product is introduced to the market, it is important that the market be understood initially. The product development process must comprehend what customers will want at the time the product will be introduced. There are numerous methodologies for determining the customers' needs, and it is not the intent of this paper to suggest a format to use. However, it is critical that a firm's design process incorporate an effective method for gathering and incorporating the customers' needs and relating those needs to the designers. A metric for a firm's ability to produce the correct product for the market is a firm's use of a methodology of determining the needs of the customer.

Strategic Importance of a Product Portfolio

Beyond the issue of matching a product to the market, in many industries, in order for a company to prosper and grow, it must develop and coordinate multiple products to cover multiple market segments. The strategy a company employs to introduce products, the overlap of product life cycles, and the way that divisions in the market are devised, is thus fundamental for the design process. A company may choose to introduce products in families and platforms to cover various segments, or a company may elect to introduce individual products. In either case, the overlap of products

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within markets, and the overlap of market requirements must be carefully considered to minimize cannibalization of products through a sound product portfolio strategy. The intent of a product portfolio strategy is to minimize duplication and maximize efficiencies through commonality while covering the needs of the entire market spectrum.

It is also important in the development process that, as a company's size increases to the point that there are multiple products in the development process at a given time, that a strategy exists for the coordination of common parts. To maximize efficiencies within the company, it is important to utilize the same parts or processes when it is unapparent to the customer, yet differentiate the products based on the product features that matter to the customers. Moreover, the firm must be able to improve the process through organizational learning.

**Importance of Product Introduction Timing**

If the manufacturing sector of a firm where to interrupt the assembly of a product partially through the process, then decide to assemble the product differently, it would be appalling. Yet this process goes on in the design sector of many firms with little regard to the absurdity of the process. Much of the change in direction of design can be attributed to poor planning, poor communication, or poor initial research. Very little change of product is truly attributed to a change in the market if the upstream work has been carried out properly. Although the initial planning may have been carried out by individuals other than the designers, changes in direction cause the development program to miss key deadlines and delay a project. It is these delays, when not countered, that cause a product introduction to be delayed onto the market.
Aside from the increase in engineering time that can cost over $300 Million per year in the automotive industry is the issue of missing a market opportunity. For cyclical products such as swimming pools, beach balls, and snow skis, a delay of a few months means missing the entire selling season. In the toy industry, missing the release date by a few weeks can mean missing the Christmas shopping rush, and negate the majority of the years sales. In a highly competitive industry such as the automotive industry, delays can result in loss of market share to a competitor. An example of this situation occurred in the case of the General Motors GM-10 program and the Ford Taurus program.

The GM-10 program was hailed by General Motors to be the new replacement for their aging mid-sized car market. The program was the most grandiose development program ever undertaken by any automotive company and was planned to represent 21% of the total U.S. car market. The multiple delays and the missed opportunities caused the GM-10 project to be labeled "The biggest catastrophe in American Industrial History" by Fortune Magazine. To understand the impact of this catastrophe, figure 1 below depicts the sales of GM verses Ford, as well as the sales by each company to the mid-sized market segment, and the contribution of sales made by the GM-10 and Taurus/Sable programs. The GM-10 program took 8 years to complete, including a redesign required to differentiate the General Motors products from the Taurus since it was upstaged by Ford in 1985.

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Prior to the introduction of the Taurus platform by Ford in 1985, General Motors dominated the sales of both *U.S. total car sales* and *car sales in the mid-sized market segment*. With the introduction of the Taurus platform, which sold under the names of Ford Taurus and Mercury Sable, Ford greatly increased the number of cars it sold in the mid-sized segment.

In 1985, Ford introduced the U.S. public to a radically styled family sedan that the customers loved. By the time General Motors produced their version in 1988, it was seen as a poor imitation of a great car. Ford, not only led the introduction of the mid-sized car design revolution, but was also able to perfect the design by the time General Motors introduced its first copy.

The delay to market seen in figure 1 resulted from Ford pulling ahead its Taurus program, while General Motors prolonged the development program of the GM-10 for
various internal reasons. The outcome of the delay from 1985 to 1988 resulted in an increase of sales in the mid-sized car segment by Ford from 282,920 in 1985 to 712,672 in 1988. During this same period, sales of mid-sized cars by General Motors dropped from 1,844,428 in 1985 to 1,198,152 in 1988. The net change of sales to the mid-sized segment was an overall addition of 1,183,772 cars sold by Ford over the three years, and 1,013,164 fewer cars sold by General Motors over the same three years. With an estimate of $3,000 that Ford makes on each Taurus it sells\(^5\), the gain to Ford was $3.5 Billion over three years, while General Motors lost $3 Billion over the same period.

The introduction of the Taurus has fueled the sales recovery of Ford, while the problems embodied in the delayed introduction of the GM-10 have been the primary drivers behind the decrease of General Motors sales in the late 1980's. The loss of General Motors sales and the rise in Ford sales shown in figure 1 occurring simultaneously between 1985 and 1987 is not coincidental. This example attests to the importance of planning and implementing product design programs.

Sources of Innovation

The final issue a company must resolve for effective product design is actually at the beginning of the design process chronology, namely the sources of innovation that a company relies on for new product concepts. The sources of innovation involve idea generation, the funnelling process that determines which of the potentially many projects a company chooses to invest in, and the strategic linkage of ideas, technologies, and customer needs.

Two important approaches for idea generation are monitoring Lead Users\(^6\) and Concept Engineering\(^7\). The notion of Lead Users involves monitoring an early subset

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\(^5\) Taylor III et. al, "Fortune," 16 November 1992, 52

\(^6\) Eric Von Hippel, *The Sources of Innovation*, (New York: The Oxford University Press, 1988)
of users that experience a need prior to the majority of users that will eventually experience the same need for the product or service. A recent study involving lead users in the automotive industry determined that lead users could be utilized to indicate general market trends, but that due to economic barriers and the level of sophistication of the products, direct innovation was minimal. Lead users in other industries, however, have been very instrumental in the introduction of new products and user innovation can be stimulated in the automotive industry.

While monitoring lead users is unstructured and open-ended, concept engineering involves a structured stepwise methodology that takes a design team from understanding the customers' environments through selecting a concept in five defined stages. Concept engineering involves a process of determining customers' key requirements, creating metrics to judge compliance with the requirements, and developing a product that satisfies the requirements.

Once ideas have been generated, there must be a process in place to reduce the number of concept ideas to a manageable amount through some type of "funnelling" process. The difference in the various funnelling processes is primarily defined by when the various screens occur in the process. One extreme involves many screens with increasingly finer criteria for ideas to pass through, while the other extreme involves "a few big bets" with a very fine screen at the onset that allows only very few projects through. In addition there are various strategies that can be employed to assure greater success of projects that do pass through screens, such as assigning key executive to projects that show merit.

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Finally, the selection of development projects must comprehend the strategic linkage of technologies with customer needs. The strategic linkage of projects is a fundamental role of management and requires managers that understand the business as well as the needs of the customers and the firm's technologies. There are various computer programs that assist management in defining the interdependencies and linkages of needs and technologies, however, it is ultimately the task of management to decide the direction of the firm and what projects to invest in.
III. GENERAL APPROACHES TO PRODUCT DESIGN

In order to understand a firm's design process there are some general approaches to product design that should be comprehended. These approaches cover various facets of the design process, and firms must determine their own philosophy regarding these issues. The firm's philosophy and approach to these issues differentiates it from the rest of the firms in an industry.

The Organization of People

One facet of design that all firms face is the organization of people. Traditionally, many firms in the U.S. and Europe have been arranged in a functional hierarchy with a chief engineer or chief designer at the top as shown in figure 2 below. In a traditional functional hierarchy individuals report through functional managers, represented by the large square, circle and triangle in figure 2, to the chief engineer. Individuals only work in their functional areas, and product coordination is done by the functional managers.

This organizational structure allows the chief engineer a great deal of power and control over the designs, and products generally carry a distinct mark of the chief engineer. Creativity is to a large extent stifled, since new ideas generally must comply with the chief's views in order to be accepted, and individuals below the functional managers do not have a good understanding of the entire product. The traditional hierarchy, however, fosters the development of in-depth functional expertise and is well suited for products that require excellence in particular functional areas, like engine design or product safety, or where there is a need for in-depth understanding of the product by only very few people in the organization.¹⁰

¹⁰ Stephen Raab, "Teaching Note on Project Management for New Product Development," Unpublished Manuscript prepared under the supervision of Assistant Professor Steven Eppinger and Assistant Professor Karl Ulrich, Sloan School of Management MIT, 1992, p.3
Traditional Functional Hierarchy Structure

In stark contrast to the traditional hierarchy, product development teams are a relatively new form of organizational structure in the U.S. While a traditional hierarchy develops functional expertise, product development teams draw on the expertise of many different people with experience in various different functional areas. The combined experience of the product team is used as a basis for decision making, rather than the in-depth experience of one individual in the functional hierarchy. Due to the nature of group dynamics and the fact that many people are involved in the decisions, products do not carry the mark of just one person, but rather the character of the group.

A generic structure of the product development team organization is shown in figure 3 below. In this figure, the large square, circle, and triangle represent various functional managers. Below the functional managers are the individuals that report to them. These individuals are indicated by the small squares, circles, and triangles.

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11 Stephen Raab, "Teaching Note on Project Management for New Product Development," Unpublished Manuscript prepared under the supervision of Assistant Professor Steven Eppinger and Assistant Professor Karl Ulrich, Sloan School of Management MIT, 1992, p.4
enclosed in the boxes. The small squares, circles, and triangles aligned with the project manager are individuals with functional experience that are assigned to the project manager to work on a project.

![Project Development Team Structure](image)

Figure 3

This example of a product development team structure is one extreme of the product team organization. In this case, individuals are taken from functional areas and assigned to a project team. When individuals are taken from functional areas and assigned to project managers, the managers are afforded the maximum amount of control over the team and the team maintains a strong project focus.

There are variations to the product team structure based on the strength of the project manager, and the strength of the relationship that individuals have with their functional group. At one extreme, product development teams can be arranged with a leader who is at a higher level in the organization than the rest of the people on the team with all the members reporting to the leader as illustrated above, or at the other extreme, a team can be comprised of equals with no organizational link and no hierarchy.
The organization depicted in figure 4 below, illustrates an example of strong linkage to the functional area and a project manager who is at a relatively low level in the organization. Individuals assigned to both the functional areas and the project only serve a liaison role. This structure is typically termed a "Lightweight Project Management" structure due to the weak influence that the project manager has over the project.\textsuperscript{12}

\begin{center}
\textbf{Lightweight Project Management Structure}
\end{center}

![Diagram of Lightweight Project Management Structure](image)

\textit{Figure 4}

When the project manager is elevated to a senior management level, and the linkage to the project team is increased beyond the level of only liaison responsibility, the influence of the project manager increases significantly. The organization depicted below in figure 5 illustrates a relationship where the influence of the project manager is very strong. This structure is known as a "Heavyweight Project Management" structure.\textsuperscript{13}


When individuals are taken from their functional areas and assigned directly to the same senior level manager that their functional manager reports to, the organization is termed an "Autonomous Team" structure.\textsuperscript{14} The autonomous team structure allows the project manager the greatest level of authority, and is depicted in figure 6 below. Autonomous teams are generally only created for short term projects that require a highly concentrated effort. Autonomous teams are effective for quickly initiating new products, or resolving problems.

Although figures 3 through 6 depict variations of matrix organizations, there is also the opportunity of creating a true matrix organization where the linkage to the functional area and the project are equal. A matrix organization is an idealized organization, and in reality it is very difficult to implement. Implementation is hampered by the fact that when there are two managers with equal weight that disagree, individuals can never keep both managers satisfied. Although it is difficult to implement, it is possible to implement if the firm's culture embraces individual decision making, and employees' expertise is developed to allow appropriate decision making. The matrix organization is depicted in figure 7 below.
The Coordination of Projects

Another facet of design that is closely related to the organization of people, is the coordination of projects. Firms must determine their philosophy regarding project coordination and what approach fits their firm best. In the case of the traditional hierarchy, all coordination is done through the chief engineer at the top. The traditional hierarchy allows for very effective coordination when there are few projects or when the projects are very small. As the scope of the projects increase, and as the number of projects increase, it becomes impossible for one individual to coordinate all aspects of the various projects.

With the introduction of matrix organizations, it becomes the responsibility of each individual to disseminate information to the functional manager and the project manager. When both the functional manager and the project manager are at an equal level in the organization, the matrix organization is the most effective in disseminating information. However, with both managers at the same level, it becomes the most
difficult to make decisions that compromise either the functional area or the project area.

**The Commonization of Parts**

The most crucial decision requiring the functional manager and the project manager to compromise are decisions relating to the commonization of parts. It is generally in the functional manager's best interest to keep all the parts the same across all projects, however, it is in the project manager's best interest to have different parts in order to differentiate the product. When the project managers become more powerful than the functional managers, it becomes very difficult for functional managers to maintain common parts, and the products become more expensive. When the functional managers become more powerful, the individual products lose their identity and there is no customer differentiation. Firms must determine the best strategy for coordinating parts while still allowing individual products to be differentiated.
IV. PRODUCT DESIGN ORGANIZATIONS WITHIN THE AUTOMOTIVE INDUSTRY

The philosophy by which the various automotive companies arrange their product design organizations and the methodology by which the product development process operates is almost as varied as the number of automotive companies. Due to the complexity and scope of vehicle design, all the companies tend to have people responsible for a vehicle divided into a team. It is the make-up of the team, the coordination of the teams, the scope of responsibility, and the authority by which the team leader manages the people and process that varies from company to company.

The Toyota "One-Man-Rule" Design Process

At Toyota the "One-Man-Rule" system of power, and the corresponding product development process is as fundamental to Toyota's success as the Toyota Production System for which Toyota is so well known.\textsuperscript{15} From 1954 through 1992, Toyota's product development process revolved around powerful engineering "shusas" or bosses who had total authority for a vehicle line.\textsuperscript{16} This "Chief Engineer" controlled everything from styling, to engineering, to manufacturing, to marketing strategy, and controlled them from the start of a project until the very end. The chief engineer led the development process through a position of power. It has been this development process that has frequently been cited as the driver behind Toyota's quick, well-focused, and highly successful vehicle programs.\textsuperscript{17}

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\textsuperscript{15} Richard Johnson, "Toyota's one-man rule vs. GM's dispersal of power," \textit{Automotive News}, (2 March 1992), 34

\textsuperscript{16} Richard Johnson, "Toyota tinkers with success; Powerful new-product bosses lose some of their autonomy," \textit{Automotive News}, (14 December 1992), 3

\textsuperscript{17} Richard Johnson, "Toyota tinkers with success; Powerful new-product bosses lose some of their autonomy," 14 December 1992, 3
In 1992, Toyota had a total of 21 chief engineers who each ran different vehicle programs. This group of all powerful program managers were known as the "21 Club" and report directly to the corporate managing director and general manager for the Product Planning Division. Vehicle coordination was done primarily through the 21 Club.

Since the chief engineer managed every aspect of the vehicle development process, the chief engineer recruited and staffed his team similar to the manner in which U.S. managers fight for funding. The power and authority that the chief engineer wielded has been likened to a navy officer with command of a ship. Toyota believed that only one person could be in charge of a program to have true simultaneous engineering, and it was the chief engineer who managed the process to assure that everything ran well.\textsuperscript{18}

In a move that Toyota insists is still in accord with the traditional One-Man-Rule process, Toyota recently created three new-vehicle development centers, and a new-component and systems center. These four development centers now have a director to whom the chief engineers report. The move to combine vehicle programs into system centers was primarily due to three reasons: 1) Motivation of Employees, 2) Communication, and 3) Fragmentation of Research and Development activities.\textsuperscript{19}

Since engineers join Toyota to work on cars and not fragmented parts, Toyota felt it important to reorganize the divisions to motivate personnel that engineered components. In addition, the restructuring was necessary to improve the time consuming communication process necessary to inform every employee of a decision under the old system. And finally, due to the complexity to which Toyota vehicles had evolved, it was necessary to combine resources that had become fragmented across Japan, the United States, and Europe.

\begin{footnotes}
\item[18] Richard Johnson, "Toyota's one-man rule vs. GM's dispersal of power," 2 March 1992, 34
\item[19] Richard Johnson, "Toyota tinkers with success; Powerful new-product bosses lose some of their autonomy," 14 December 1992, 3
\end{footnotes}
Under the new system, Toyota has a Rear-drive vehicle development center for large and luxury cars, a Front-drive vehicle development center for high volume cars, a Recreational vehicle development center, and a Component and system development center to support the other three. Each of these centers has its own support operations, and will focus on different segments of the market. The change will primarily consist of an additional level of control between the vehicle chief engineers and the corporate managing director to coordinate development efforts. Toyota anticipates that this new organization will allow for a reduction in personnel elsewhere in the vehicle development process.

The Ford Design Process

At Ford, program managers are responsible for coordinating the design efforts of a team from the initial proposal to a finished product. A program manager position is considered a middle management assignment that senior managers look to for ideas. Program managers are assigned to each product team and although they have no direct authority, they have the responsibility of leading through consensus.

Given the case of a new product introduction or a redesign of an existing product, a program manager will investigate the need for a given change and then develop the ground work for a proposal. This proposal will be presented to the program manager's superiors, and together they will develop a complete business plan. The business plan will include an outline of the changes including data to support the need for the change, as well as tooling and facilities costs, engineering costs, and marketing costs.

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21 Kathy Jackson, "Assignment: Update a classic; Ford engineer takes initiative to redesign full-sized vans," 17 June 1991, 3
Once a business plan is completed, the plan must be presented to Ford's 25-member product planning committee. The product planning committee is chaired by Ford Motor Company's president, and membership includes Ford's chairman, the Ford Automotive Group president, the Chief Financial Officer, and the president of Ford Motor Credit Co. This committee meets six to eight times per year and must approve all product changes, as well as allocate the required funding. There are four broad reasons for which the committee will approve and allocate funds.\(^{22}\) These reasons are:

- Quality Improvements
- Customer Requirements
- Competition
- Cost

Once a project has been approved it will be assigned to a team to carry out. Up to 2,000 people will work on a project throughout its life, and individual workers are generally afforded extensive freedom in carrying out their responsibilities. In establishing the design of a vehicle, primary users and hourly workers are generally included in the decision process early-on in order to contribute their ideas. In the case of the Econoline for example, commercial users, van converters, and individuals who use Club Wagons, as well as hourly workers were included early in the design process.\(^{23}\)

**The Chrysler "Team" Design Process**

In 1989 Chrysler eliminated its centralized engineering hierarchy and established four autonomous platform teams. These teams include personnel from

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\(^{22}\) Kathy Jackson, "Assignment: Update a classic; Ford engineer takes initiative to redesign full-sized vans," 17 June 1991, 3

\(^{23}\) Kathy Jackson, "Assignment: Update a classic; Ford engineer takes initiative to redesign full-sized vans," 17 June 1991, 3
engineering, procurement, manufacturing, design, strategic development, sales and marketing, and finance, as well as some key outside suppliers. The four platform teams are:

- **Small-car operations** headed by the vice president of product strategy and regulatory affairs.
- **Jeep and Truck operations** headed by the vice president for vehicle engineering.
- **Minivan operations** headed by the vice president of product design
- **Large car operations** headed by the vice president of procurement and supply.\(^{24}\)

According to Bob Lutz, Chrysler's president, "The platform teams have 'absolutely broad latitude' in developing a vehicle. ... They have full accountability for managing the allocated investment, meeting variable cost targets and meeting all the quality and vehicle performance targets. They all work together with suppliers."\(^{25}\) The system is intended to improve efficiency and save money through teams agreeing on specifics of the vehicle at the onset of the program. To give a sense of platform size, in the case of the ZJ Jeep program, about 1,000 people were assigned to the platform team.\(^{26}\)

The way that the design process works at Chrysler, is that when marketing research determines the need for a new vehicle, or revision to an existing vehicle, they will present their findings to the corporate executive committee. The corporate executive committee is comprised of:

\(^{24}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," *Automotive News*, (10 June 1991), 10

\(^{25}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 10

\(^{26}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 10
- The chief executive officer
- The company president
- The executive vice president of the corporate staff group
- The vice president, general counsel and secretary
- The vice president of personnel, administration and development
- The executive vice president of finance and chief financial officer

The executive committee will be presented with advanced vehicle studies relating to design and packaging, engineering features, and manufacturing feasibility and marketing expectations.\(^{27}\)

Following the corporate executive committee approval, the platform team prepares line item details about the program for approval by the product planning committee. The product objectives include vehicle performance, fuel economy, wind noise, noise/vibration/harshness targets, weight, and financial objectives such as variable cost, margins and investments. The product planning committee is chaired by the company president, and members include all the platform team heads, the vice president of international operations, the executive vice president of sales and marketing, the vice president of marketing, the vice president of sales, the vice president of manufacturing, and the vice president of employee relations.\(^{28}\)

According to Bernard Robertson, general manager of Jeep-Truck engineering, "The product planning committee's approval is basically an agreement that the stated objectives, the design theme, the vehicle content, the margins, the return on investment and so on all fit the basic corporate criteria and that it will be a competitive product. After that time, the basic management of the program is by the platform team."\(^{29}\)

\(^{27}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 1

\(^{28}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 1

\(^{29}\) Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 1
The platform team will create a book outlining all the objectives approved by the product planning committee. Periodic reviews will then be conducted to determine the project status with regard to each target. The platform team will hold monthly development reviews for the platform team head, the company president, and senior executives. The presidential program review is held monthly to review the program objectives and the status of the program. The senior executive review is held quarterly during the development process to monitor program progress and to test drive prototype and pilot vehicles.\textsuperscript{30}

\textsuperscript{30} Mary Connelly, "Chrysler platform teams nail down specifics at start of vehicle program," 10 June 1991, 1
V. CASE STUDY OF PRODUCT DEVELOPMENT AT GENERAL MOTORS

History

From the inception of General Motors and the creation of General Motors as a corporation by Mr. Durant in the early 1900's, General Motors could best be described as a decentralized conglomeration of businesses remotely associated with automobile production. During the growth period of General Motors, the expansion of the company was fueled by the acquisition of profitable companies that provided a service to the company prior to joining the corporation. These companies continued to operate on a very autonomous basis, and through the 1908 - 1910 and 1918 - 1920 periods of economic expansion, the companies continued to turn a profit and provide a revenue stream to the corporation.

By 1921, however, it became clear that greater control over the companies would be necessary. This was primarily based on the need for greater financial control, but the need for better coordination of a product strategy was also beginning to be recognized. The automotive companies of the day primarily designed and built only one vehicle model. Even Ford with a 60% market share sold only two cars; a high-volume low-priced Ford, and a low-volume high-priced Lincoln. General Motors on the other hand provided 10 different models under 8 different autonomous companies which overlapped in price as shown in figure 8 and figure 9 below.\(^\text{31}\)

General Motors Vehicles (1921)

<table>
<thead>
<tr>
<th>Company</th>
<th>Model</th>
<th>Price range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevrolet</td>
<td>four-cylinder (&quot;490&quot;)</td>
<td>$795 - $1375</td>
</tr>
<tr>
<td>Chevrolet</td>
<td>four-cylinder (&quot;FB&quot;)</td>
<td>$1320 - $2075</td>
</tr>
<tr>
<td>Oakland (Pontiac)</td>
<td>six-cylinder*</td>
<td>$1395 - $2065</td>
</tr>
<tr>
<td>Olds</td>
<td>four-cylinder (&quot;FB&quot;)</td>
<td>$1445 - $2145</td>
</tr>
<tr>
<td>Olds</td>
<td>six-cylinder*</td>
<td>$1450 - $2145</td>
</tr>
<tr>
<td>Olds</td>
<td>eight-cylinder</td>
<td>$2100 - $3300</td>
</tr>
<tr>
<td>Scripps-Booth</td>
<td>six-cylinder*</td>
<td>$1545 - $2295</td>
</tr>
<tr>
<td>Sheridan</td>
<td>four-cylinder (&quot;FB&quot;)</td>
<td>$1685</td>
</tr>
<tr>
<td>Buick</td>
<td>six-cylinder</td>
<td>$1795 - $3295</td>
</tr>
<tr>
<td>Cadillac</td>
<td>eight-cylinder</td>
<td>$3790 - $5690</td>
</tr>
</tbody>
</table>

* Common engine made by Oakland

Source: Sloan Jr.\(^{32}\)

Figure 8

General Motors Vehicles (1921)

![Graph showing price range for different models of General Motors Vehicles (1921)]

Figure 9

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\(^{32}\) Sloan, Jr., p 59

\(^{33}\) Sloan, Jr., p 59
Since each company (division by this time) operated autonomously on a profit generating basis, the greatest concentration of models was in the most profitable segment of the market. There was no established product policy for the car lines within the corporation. In light of the overlapping products and no representation in the high-volume low-price segment, it was clear that coordinating action must be undertaken. On April 6, 1921, the Executive Committee established a special committee of Advisory Staff to develop a product policy. By June 9, 1921 the study had been completed, and it is this basic policy that General Motors eventually became known for: "A car for every purse and purpose".

The product policy that was proposed involved three key elements:

1. *The corporation should produce a line of cars in each price area, from the lowest price up to one for a strictly high-grade quality-production car, but … would not get into the fancy-price field with small production.*

2. *The price steps should not be such as to leave wide gaps in the line, and yet should be great enough to keep their number within reason, so that the greatest advantage of quantity production could be secured.*

3. *There should be no duplication by the corporation in the price fields or steps.*

Moreover, the principle to making this product policy work required separating out related price classes. Mr Sloan recorded the decision of the Executive Committee as follows:

We proposed in general that General Motors should place its cars at the top of each price range and make them of such quality that they would

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34 Sloan, Jr., p 65
attract sales from below that price, selling to those customers who might be willing to pay a little more for the additional quality, and attract sales also from above that price, selling to those customers who would see the price advantage in a car of close to the quality of higher-priced competition.35

With the basic Ford Model T selling for $495 as a benchmark, the ideal cost structure for the separate price classes was established as follows in figure 10 and figure 11.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$450 - $600</td>
</tr>
<tr>
<td>B</td>
<td>$600 - $900</td>
</tr>
<tr>
<td>C</td>
<td>$900 - $1200</td>
</tr>
<tr>
<td>D</td>
<td>$1200 - $1700</td>
</tr>
<tr>
<td>E</td>
<td>$1700 - $2500</td>
</tr>
<tr>
<td>F</td>
<td>$2500 - $3500</td>
</tr>
</tbody>
</table>

Source: Sloan Jr.36

Figure 10

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35 Sloan, Jr., p 67
36 Sloan, Jr., p 67
Even with the establishment of a marketing position for the vehicle line, and the establishment of the divisional hierarchy, the coordination of product commonality was still a problem. General Motors never attained the ideal price breakdown or product hierarchy. Although there was an attempt to coordinate models in order to cover the market, the vehicles were still separately designed and the divisions were operated on a decentralized basis. The divisional management had control over the design and content of the vehicles. The organizational chart in figure 12 below from 1925 depicts the many different divisions and the difficulty involved in coordination.

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37 Sloan, Jr., p 67
The first attempt to develop common components for General Motors vehicles involved the "Copper-Cooled" engine. The Copper-Cooled engine exemplifies the problems associated with coordinating a common design among divisions that have differing views on the need for the product and the nature of the design. The functional managers and the project managers could not compromise on a design so the copper-cooled engine was never produced in General Motors vehicles. Through the

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38 Sloan, Jr., p 115
years, however, the coordination of components has progressed to the point that divisions do use common parts.

The basic organizational structure of General Motors with regard to product design and development remained virtually unchanged from that depicted in the 1925 organizational chart until 1984. Some divisions have entered the corporation, some have left, and some divisions have merged or changed their names, but the basic structure has remained in tact.

The basic product policy established in 1921 was so successful that General Motors eventually ascended to the pinnacle of the automotive industry. But according to Maryann Keller, "as the company gained in stature and actually succeeded in becoming number one, the adrenaline rush of striving for a competitive edge sputtered and died. No longer was GM battling against a surge of competition. It had attained its status as the leader, and eventually became ingrained into the corporate philosophy: General Motors could do no wrong."

By the mid 1970's the product policy established in 1921 had become blurred. There was no longer a distinct hierarchy in the products that each division offered, more over, the products lost their distinctiveness between divisions. The ails of the company in the early 1980's can best be described as a lack of coordination between divisions, and a lack of communication over the design, development, and assembly of vehicles. "General Motors did not operate as one cohesive corporation, but rather, as seven separate and distinct operations, each with its own insulated empire. It took three separate operations - a car division, Fisher Body, and GMAD [General Motors Assembly Division] - to build a car. And at no time did they interface, except through the president. They were entirely vertical organizations. ... A car division would approve the design of the car and turn it over to Fisher Body. Fisher would engineer the body to conform to the design, sign off, and send it to GMAD. GMAD would then

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modify plants and equipment to prepare for the new model. Later GMAD would have
the responsibility for assembling the car. At no point was there interaction among
lower-level people. All divisions reported ultimately to the president, who was
responsible for arbitrating disputes."40

When one considers the fact that each of the divisions involved are expected to
show a profit with the executive bonuses calculated on this bases, and that the public
would buy anything that General Motors could produce, the demise of General Motors
was inevitable. "There were myriad problems with the way the system worked.
Created during simpler times, when there were fewer models, less engineering
complexity, and no urgency about keeping costs down, the system had become a
dinosaur. The structure of autonomy that separated the car divisions, Fisher Body, and
GMAD was ill-suited to the building of the new unibody cars, or to addressing the new
imperatives of getting cars to market faster at a lower cost."41 In January of 1984,
Roger Smith announced that major organizational reforms would take place at General
Motors to address the ails of the outdated structure.

The Reorganization

The reorganization announced in January of 1984 put to rest rumors relating to
the impending changes outsiders saw as inevitable for the company. The plan called
for the abolition of Fisher Body and GMAD with their responsibilities assigned to two
new automaking groups. The bulk of the five car divisions, Fisher Body, GMAD, and
GM of Canada were blended together to form these new groups. One group was
comprised of Buick - Oldsmobile - Cadillac called BOC, the other was comprised of
Chevrolet - Pontiac - GM Canada operations called CPC.42 The actual make-up of the

40 Keller, p 100
41 Keller, p 101
42 Joseph M. Callahan, "Cunningham describes his reorganization; General Motors vice-president,
organizational structure within the two groups was largely left up to the executives in charge. Robert Stemple was assigned the BOC group with the responsibility of engineering mid-sized and large front drive cars. Llyod Reuss was assigned the CPC group with the responsibility for engineering small and rear drive cars. Although this was the principle behind the assignment, both groups ended up with small, mid-size, and large cars.

The CPC group established its mission as preserving GM's share in the small-car segment of the market. CPC "transcend[ed] individual car lines, [and took] a 'mission oriented' tack [by] centralizing almost all of its operations by discipline."\(^43\) BOC, however, was "cast more in a defensive role of protecting GM dominance in the upper-sized and price range, the Buick-Oldsmobile-Cadillac Group ... delegat[ed] cradle-to-grave responsibility for individual cars ... and attendant support functions such as personnel, purchasing and finance ... by product platform."\(^44\) With the Chevrolet and Pontiac organizations located very close together geographically, it was very easy to establish a new centralized organization. On the other hand, the fact that Cadillac was located in Detroit, Buick in Flint, and Oldsmobile in Lansing made BOC better suited for the decentralized organization that was selected.

As the two groups evolved, CPC took shape much faster than BOC. This is because CPC was essentially one large division in the form of Chevrolet, and one small division, Pontiac, with the addition of a small marketing organization and a few assembly operations in Canada. In the end CPC resembled a scaled down copy of GM prior to the reorganization with body design and assembly thrown in. Although the level of coordination between marketing, engineering, and manufacturing was moved down the organization, it was by no means reduced to the lower level employees.

"Essentially, Reuss replaced GM's so-called matrix management structure, a series of

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\(^43\) Dean Winter and Jon Lowell, "Supergroups: a year's training done, they boldly head where none have gone before," *Ward's Auto World*, (21 March 1985), 55

\(^44\) Winter et. al, "Ward's Auto World," 21 March 1985, 55
functional departments on an organization chart, with everyone inflexibly positioned in his given vertical channel. There was no provision for cross-channel communication, except through him."45

Meanwhile, the reorganization process at BOC evolved much more slowly. Bob Stemple did not implement the reorganization directives, but rather gathered his staff and studied the competition. Stemple's philosophy was that given the opportunity to restructure, why not study what the market would be like in the future and restructure accordingly.

The results of the studies indicated that if BOC followed the plan recommended by McKinsey consulting company as Reuss had done, the two groups would simply become two little GM's. Fisher Body and GMAD would be eliminated, but the organization would be no closer to the customers, and there would still be no mechanism for interdepartmental communication. Stemple wanted an organization that was product oriented, and could react fast. As a result, BOC proposed further changes to the previously announced plan, and over an additional 18 months created three vehicle platform organizations. Each platform had the capability of engineering and building the vehicle assigned. The rigid organizational chart of the past would be abolished.

"The concept was that the group would be organized around product teams that would have direct responsibility for the product - and more direct accountability, as well. The point ... was to go for parallel and concurrent and simultaneous engineering to ensure that there's at least an understanding and an empathy with [what] the guy ahead and the guy behind you were doing. And the product leader would be responsible for everything."46

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45 Keller, p 120
46 Keller, p 121
Stemple's plan was a drastic departure from the traditional GM hierarchy, and was rejected out of hand. Stemple was commitment to the correctness of the plan and persisted to drive the proposal through. In the end, the General Motors executive committee gave only a reluctant approval to proceed.

The different personalities of the two groups provided GM with the benefit of two laboratories to study organizational change. CPC evolved as a centralized, integrated organization with the consolidation of purchasing and finance and only one business unit. BOC developed into a decentralized, product-team-based organization.

Although many executives continued to warn about judging the effectiveness of the two groups too soon, by 1991 it had become apparent that the BOC system was far more effective. According to the auto analyst Maryann Keller, "What Stemple did at BOC in 1984 was extremely controversial inside GM at the time, but it has proven to be the better system." 47

**The Product Team Organization**

The unintentional diversity in the organizational structure of BOC and CPC proved to be beneficial since it made it easier for the conservative management of General Motors to recognize the merits of the BOC initiatives. In June of 1991, GM announced that as a part of its continuing efforts to improve the efficiency and profitability of its North American Operations, CPC would adopt the Product Team Organizational Structure pioneered by BOC. 48 Like BOC, CPC will have one platform manager with total responsibility for all vehicles produced from the platform. The platform manager will have engineering, finance, and purchasing employees report to him.

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47 Liz Pinto, "C-P-C adopts Stemple’s old formula for B-O-C; Team system aids platform planning," *Automotive News*, (17 June 1991), 6
48 Liz Pinto, "C-P-C adopts Stemple’s old formula for B-O-C; Team system aids platform planning," 17 June 1991, 6
The grouping of employees in teams serves several important functions in improving efficiency. By assigning responsibility of the entire vehicle to one individual, it is possible to assign accountability. With accountability, it is no longer possible to sidestep customer issues. The responsibility of providing the customers with what they want is funneled to one key executive.

The Aggregate Product Portfolio

Although the adoption of product teams goes a long way to commonize efforts, the number of individual platforms still remains an issue that needs to be addressed. As discussed earlier, one of the fundamental themes that brought General Motors to prominence was their product policy: "A car for every purse and purpose". General Motors became the low cost producer by spreading the cost of engineering product variety among very few platforms. Providing total market coverage at lowest cost was the key to gaining market dominance. This product policy which leverages commonality among different models allows less expensive prices than those of the competitors who specialize. No company was better at providing product variety at minimal cost than General Motors was throughout the first half of this century. However, years of incredible success caused General Motors to lose sight of the fundamental principles supporting this success. After the 1973 oil shock when the company began to down-size products, new vehicles were added that did not fit the platform scheme. As management reacted to the changing demand, rather than adjust the platform basis to accept the new trend, individual product lines came into the company's product line-up.

As the new products entered the corporate portfolio, each required additional resources to support it. Rather than build a variety of cars on the same platform as in the past, management changed their philosophy. They created a new platform and staffed it with additional engineers and workers. As management reacted to the shift in
consumer demand, not only did they add product lines to the product portfolio, but as the vehicles were redesigned, they began to overlap in size and price. General Motors created too many similar products all aimed at the same markets. These are not "look-alike" cars, but different products marketed to the same customers. The current situation is shown in figure 13 below, depicting vehicle size (wheelbase) against base price.

The graph shows a clustering of products rather than the distinct hierarchy that the 1921 product portfolio strategy dictated. The only possible exception to the clustering is Cadillac with its products aligned in the premium segment of the market.

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The initial attempt to revert back to the product strategies of the past occurred when Bob Stemple introduced product teams in the BOC organization. Initially the J and N platforms were assigned to the Lansing (Small Car) team, the E, C, and H platforms were assigned to the Flint (Bigger Cars) team, and the K and V platforms were assigned to the Cadillac (Large Luxury Cars) team.

By 1990 the L platform had joined the Small Car team, and in 1991 CPC reorganized its platforms into two additional product teams. The Front Drive team was responsible for the A, U, and W platforms, and the Rear Drive team was given the B, D, F, and Y platforms as depicted in figure 14 below.
Reports indicate that further unification is still under way. The C and H cars have already been combined, and "eventually, the J cars, the L cars, and the N cars will be built on the same platform reducing three platforms to one. The A and the W cars will probably also merge." These seven platforms currently account for 75% of General Motors' volume.

Although changes in the platform structure continue to occur, and a shift has begun from the line management structure to the team organizational structure pioneered by BOC, it would be interesting to investigate the effectiveness of the team structure. Since both CPC and BOC were formed at the same time, with CPC opting for a traditional managerial hierarchy and BOC pioneering a new team based organization, it allows an opportunity to study the effectiveness of the team process in an organization. Although this is not an entirely scientific study due to uncontrolled external factors, when the sales of the vehicle platforms that make up the bulk of each organization are plotted against time, an idea of the organizational effectiveness can be seen. Appendix 3 shows the data for nameplate sales from 1981 through 1991. When the A, W, B, D, F, and Y platforms are used for a measure of CPC's effectiveness,

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and the J, N, L, C, E, H, K, and V platforms are used for a measure of BOC's effectiveness, a reasonable approximation for organizational effectiveness can be determined when compared against US domestic vehicle sales. This data is plotted in figure 15 below.

![Sales Volume per Year](image)

Data: See Appendix 3

**Figure 15**

Although figure 15 does not give information on the profitability of the two different organizational structures, it does imply that the BOC organization was better able to provide for the needs of the customer as indicated by higher sales. Further study with more complete data would be necessary to accurately compare the effectiveness of the team structure. One point, however, is clear General Motors must see merit in the BOC organization since it is changing the CPC structure to imitate
BOC. In addition, there is a move from individual vehicle lines and platforms to common product teams.

Platform Commonization

As of 1992 General Motors required a total of 19 different vehicle platforms to cover the US. market. Ford, however, requires only 6 platforms to cover the same basic market, and Chrysler builds sedans, convertibles, minivans, and larger mid-priced cars all from their K platform. The need for common platforms or teams is self evident when the economies of scale are considered for the engineering and implementation of vehicle designs. In addition, a common basis for the vehicle allows the assembly plant greater flexibility of products to make, and allows the company to smooth production schedules to meet the rise and collapse of sales as vehicles age.

There is reportedly a plan under way to commonize platforms within General Motors, but the extent of the commonization is difficult to determine based on public information. In particular, the difference between a "Platform" and a "Product Team" is unclear. The plan compiled from public sources indicates that General Motors will move to consolidate 16 current car platforms (this does not include Saturn, Pontiac Lemans, or Geo cars) into 5 platforms or teams in the future as shown in figure 16 below.

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52 Liz Pinto, "C-P-C adopts Stemple's old formula for B-O-C; Team system aids platform planning," 17 June 1991
**The Vehicle Engineering Process**

In order to further understand the make up of the General Motors organization, and the managerial structure, it is important to understand the basic overview of the Vehicle engineering process. In a product as complex as a car the coordination of the various functions, the break-up of the various areas to be engineered, and the timing for completing and integrating the various functions is very critical. From a financial stand point it is also important that the engineering feasibility of the vehicle be evaluated periodically during the development process. These feasibility reviews are

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Phil Frame, "GM seeks most bang for the buck; Capital cutbacks put immediate focus on high-profit lines," *Automotive News*, (5 August 1991), 1
Jack Keebler, " New GM system isn't all that simple," *Automotive News*, (23 November 1992), 3
intended to allow changes be made or programs to be canceled if insurmountable problems arise while relatively little money has been invested.

In a generic vehicle development program, there are generally five broad steps or processes involved. In general these are not clearly identified functional steps, but rather conceptual stages that the program must pass through in order for the plant to produce vehicles. Somewhere within each of these five stages there must exist opportunities for feasibility reviews, in order to make changes before proceeding with the project or cancelling the project. The notion of a car being designed cosmetically by one group, then being passed off to another group to be engineered, and then passed off to a final group to be manufactured has fortunately been abolished. The five basic generic stages of vehicle development used today facilitate simultaneous engineering, and involve a Pre-Concept stage, a Concept stage, a Clay Freeze stage, a Prototype and Test stage, and finally a Production stage.\(^\text{55}\)

The Pre-Concept Stage

In the initial Pre-Concept stage, long lead items are started, and new technology feasibility studies are conducted. It is important that major long lead items such as a new powertrain be developed with the vehicle, so during this stage, the vehicle planners and marketing researchers begin discussing concepts with designers and engineers. This initial dialog is intended to determine new technologies or engineering break-throughs that may fulfill customer needs. During this period virtually anything goes. Many of the technologies are not yet apparent to the vehicle customers, and marketing usually builds these new ideas into show cars to test customer response to the ideas.

\(^{55}\) Gerry Kobe, "Engineering; A Car is Born, part 2," \textit{Automotive News}, 169, No. 9 (September 1989), 42
The Concept Stage

By the time the vehicle enters the Concept stage, a basic idea of the vehicle that reflects the needs of the customer has been identified. There is a basic understanding of the vehicle make-up and the target markets have been identified. Normally a preliminary business plan will have been completed and a fixed fund set aside to proceed. The Concept stage no longer allows for break through or unproven technology since this stage involves the initial mock-ups of the vehicles. The notion is that engineers want to use existing systems and components, rather than develop the components while also packaging all the parts.

While engineering is building the mechanics of the vehicle with wood, Styrofoam, and tape, the designers are in the process of converting artistic renderings of the new car into 3-dimensional clay forms. There is, out of necessity, a great deal of communication required between the two parties at this point since there must be a trade-off between the two parties for space, occupant packaging, weight distribution, and crashworthiness constraints. Also, suppliers are brought into the process at this point to offer ideas on systems that they can provide. Generally, no contracts are written at this time, but suppliers who participate have a better opportunity for the business when their systems are designed in from the start. The goal of the concept stage is to evaluate alternatives so as to define the best feasible solution and freeze the design. Although a great deal of work has been done at this point, it is estimated that less than 10% of the total engineering cost involved in a complete vehicle program will have been spent through the end of this stage.\(^{56}\)

Clay Freeze Stage

The Clay Freeze refers to the fact that the designers clay forms can no longer be altered at this point. The preceding two stages have been primarily intended to allow

\(^{56}\) Gerry Kobe, "Engineering; A Car is Born, part 2," September 1989, 42
engineers and designers to change things, but at this point there are no additional changes allowed. Prior to the clay freeze, the project managers will have established a timing chart in order to coordinate the various different disciplines now involved in the project. A complete business plan will also have been developed and approved.

In the Clay Freeze stage the vehicle is engineered and designed according to the concept deemed best in the previous concept stage. No new inventions or material changes are allowed at this point unless it jeopardizes the outcome of the program. Experimental versions of the vehicle and subsystem are constructed and tested in this stage, and the assembly feasibility of the vehicle is analyzed by means of an experimental production facility. Progressive companies will involve hourly workers from the assembly plant at this stage to suggest improvements, or provide insight into the problems that the design may face. The manufacturing facility will generally begin tooling in this stage in order to be able to accept the vehicle upon completion.

**Prototype and Test Stage**

The Prototype and Test stage involves the construction of the vehicle from "soft" or inexpensive tooling in order to evaluate the vehicle under all conditions. A significant number of vehicles are generally required at a cost of approximately $300,000 each in order to test the crashworthiness, conduct noise and vibration tests, vehicle integration tests, durability tests, and specific system tests such as cooling and brakes. The intent of this stage is to identify any possible problems or issues that may arise with the design, and refine the vehicle prior to production.

**The Production Stage**

The extent to which these first stages have been conducted dictates the success of the fifth and final stage - Production. The production stage will involve the construction of pilot vehicles on the assembly line built from parts made on production
tooling. The pilot vehicles are used to train the workers on the assembly line, and these pilot vehicles will not be sold to the public, but used for additional testing. Following the pilot vehicles, the first saleable vehicles will be built at a reduced line rate to allow workers to become accustomed to their new jobs. The reduced line rate will be gradually increased according to a "ramp-up" schedule. Once the workers have been trained, and the line is up to normal speed, the production stage evolves into a continuous improvement mode.

**Program Management Framework at General Motors**

The structure under which General Motors carries out the stages of the vehicle development process described above is through a framework introduced in the 1980's, called the "Four Phase Process"\(^{57}\). This framework is very similar to the Tollgate process employed by General Electric\(^{58}\) and affords management the greatest level of control over multiple projects. The Four Phase Process has been called the "Constitution of carmaking" in General Motor's government because it paces the process for designing cars.\(^{59}\)

Although the framework is termed Four Phase, the process actually has a fifth phase conducted prior to entry into the formal Four Phase process. The five phases of the process roughly correspond to the generic five phases described above. A diagram depicting the process is shown in figure 17 below and consists of phases zero through three, as well as a "Bubble-up" phase prior to formal entry into the Four Phase process. As in the case of the GE Tollgate process, the Four Phase process not only coordinates the timing of the projects, but also administers program reviews prior to entry into each subsequent phase of the process. The gates that allow the program to progress into the

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\(^{57}\) Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on the road sooner," *Automotive News*, (22 February 1993), 3

\(^{58}\) Wheelright et. al, 157

\(^{59}\) Phil Frame, "Process, not players, is king," *Automotive News*, (3 June 1991), 34
next phase consist of an in-depth managerial program review, in addition to an engineering review involving not only platform engineers, but corporate system experts, and "shadow" engineers assigned from other platforms. The approval to proceed is given via an executive committee following the technical review and an in-depth analysis of the business case.

![Diagram](image)

Source\(^{60}\)

Figure 17

**Bubble-up Stage**

The initial Bubble-up phase of the Four Phase process is primarily a dreaming stage. Anything is possible in Bubble-up, and pushing technology is encouraged. The Bubble-up phase is the time for invention, and there is no specified exit date assigned while in Bubble-up. As the name implies, this is a time for ideas to bubble up to the

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\(^{60}\) Gerry Kobe, "Engineering: A Car is Born, part 2," September 1989, 42
surface. Bubble-up involves ongoing strategic business analysis, developing new
technology, and conducting market research.

In order for a program to enter Phase zero from the Bubble-up phase, a
preliminary business plan must be approved and preliminary level one specifications
must be complete. Level one specifications are generally abstract, and define the basic
size, performance, and option content of the vehicle. Entry into Phase zero is through
executive committee approval only. As soon as a project exits the Bubble-up phase all
the subsequent key dates are identified, and the project is included on the corporate
timing charts.

Phase Zero

Phase zero begins the actual development process, and development continues
through the end of phase one. Phase zero is the concept and technology development
stage when customer research is conducted, vehicle models are built, and the
packaging, engineering, and manufacturing feasibility of the program are evaluated.
Phase zero begins with the development of the product proposal, followed by a concept
direction approval by the executive committee at the group level, and concludes with
vehicle definition. In order to pass from phase zero to phase one, the project must pass
concept approval by a joint executive committee at the group level and the product
performance group.

Phase One

Phase one involves development of the product and process, as well as
validation of prototype vehicles. Upon entry into phase one, the funding for long lead
items is approved, and work begins immediately. Phase one involves the design and
engineering as well as construction of prototype vehicles and construction of long lead
tooling. The transition from phase one to phase two again requires a joint approval
from the executive committee, and the product performance group. With the
completion of phase one, the project transitions from a development stage to an
execution stage.

Phase Two

In phase two, the process validation occurs, as well as a confirmation that the
product meets all the criteria. During phase two the facilities are prepared, followed
by the building of pilot vehicle on the assembly line. The transition from phase two to
phase three involves the fourth and final gate in the process. This is the last
opportunity to delay the program or make changes prior to production. The final
approval is given by the executive committee at the group level, and the committee
authorizes production of the vehicle. Production approval is given based on the
performance of the project through the first three phases, and the status of the pilot
vehicles from function testing, and the quality of the pilot vehicles that were
constructed.

Phase Three

The fourth and final phase is the production and continuous improvement phase.
This phase lasts indefinitely in the four phase process, and involves the continuous
production of the vehicle coupled with ongoing improvement efforts. All five phases
are generally conducted simultaneously for ongoing platforms, with different model
change introductions staggered over time according to the planned product life cycle.

Organizational Structure

Although General Motors uses many different types of structures ranging from
hierarchical functional structures to autonomous team structures, the best description of
the basic vehicle development organization currently being used is a "mediumweight"
project manager structure. The term "mediumweight manager" reflects the recent shift away from a functional approach, to a team oriented approach, but currently, the project manager is not given full responsibility of all disciplines as in the case of a heavyweight manager.

The structure of the CPC organization as of 1991 involves seven distinct vehicle platforms. Each vehicle platform has a platform manager who oversees the entire vehicle and reports to the vice-president responsible for CPC. Although no one directly reports to the platform manager, he has all the necessary functions required for developing a vehicle assigned to him. Depicted below in figure 18, is a hypothetical organization chart indicating the organization of personnel. The titles are artificial since the intent of the diagram is to indicate organization of people only. The heavy lined boxes depict the manager to whom the individual reports and the double lined boxes depict the manager to whom the individual is assigned. The managers at the top and side of the matrix are at a higher level in the organization than the individual in the center where the management responsibilities cross.
### Functional Managers

<table>
<thead>
<tr>
<th>Platform A Manager</th>
<th>Platform A Engineering Director</th>
<th>Platform A Development Manager</th>
<th>Segment X Marketing Manager (Buick)</th>
<th>Segment X Marketing Manager (Chevrolet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform B Manager</td>
<td>Platform B Engineering Director</td>
<td>Platform B Development Manager</td>
<td>Segment Y Marketing Manager (Buick)</td>
<td>Segment Y Marketing Manager (Chevrolet)</td>
</tr>
</tbody>
</table>

---

### Functional Managers

<table>
<thead>
<tr>
<th>Chassis Group</th>
<th>Body Group</th>
<th>Electrical Group</th>
<th>Powertrain Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform A Engineering Director</td>
<td>Platform A Chassis Manager</td>
<td>Platform A Body Manager</td>
<td>Platform A Powertrain Manager</td>
</tr>
<tr>
<td>Platform B Engineering Director</td>
<td>Platform B Chassis Manager</td>
<td>Platform B Body Manager</td>
<td>Platform B Powertrain Manager</td>
</tr>
</tbody>
</table>

Figure 18
The most notable presence, and the individual with the greatest authority following the platform manager is the platform engineering director (sometimes referred to as the chief vehicle engineer). The platform engineering director also has no one directly reporting to him but is assigned all the system engineering disciplines required for the vehicle. This includes the Chassis manager, the Body manager, the Electrical manager, and the Powertrain manager. All of the systems managers except for the Powertrain manager have their subordinates collocated with them at the platform location.

The system managers either have engineering personnel reporting directly to them, or they have individuals assigned to them that actually report to one of the internal component divisions. The engineers that report to the system managers are called release engineers, and are generally assigned a basic system or set of parts such

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61 VATS (Vehicle Anti-Theft System), SIR (Supplementary Inflatable Restraints)
as the brake system, or the hood and related hardware. The release engineers perform the bulk of the actual engineering, and are responsible for the design and development of systems or parts, and subsequent coordination of their respective systems or parts with the assembly plant. Any detailing or design work is done via a request by the engineer to the drafting department.

The drafting department is divided by functional areas such as chassis, or body, and each vehicle has a design supervisor with a number of designers reporting to him. The level of authority of the design manager is at par with the release engineers. The design managers report in a functional structure through the design organization. The designers are grouped by function such as body or chassis area and then functional areas are grouped across platform lines. This is in contrast to being grouped by functional area, then by platform. Designers are grouped by functions to allow for coordination of common parts and systems, as well as building functional expertise.

The next highest level of authority of personnel assigned to the platform manager following the platform engineering director is the development manager. The development manager is at the same level in the organization as the platform engineering director, but generally holds a little less clout. The development manager is not collocated with the platform team, but rather located with his functional group at the Milford Proving Grounds. The development manager reports through the engineering organization (Current Product Engineering) at the Proving Grounds and has a number of engineers and technicians reporting directly to him.

Following the development manager, the individual with the greatest authority is the director of marketing who is at the same organizational level as the platform engineering manager and the development manager. The marketing director reports to the nameplate organization such as Chevrolet or Buick, and in the case of platforms that engineer vehicles for more than one nameplate, there may be more than one marketing director. The marketing organization is generally quite removed from the
platform team both geographically and functionally. The marketing organization is generally represented on a liaison relationship through assignment of a subordinate of the marketing manager. This, however, can vary depending on the situation involved. The marketing organization is arranged functionally based on market segments, such as sporty car segment, mid-size, etc.

Also assigned to the platform manager are representatives from the various functional staffs such as finance, program management, service technologies, and design staff. These individuals all play a liaison role and the level of coordination is somewhat diminished in these areas. Since the platform manager carries sufficient clout, this is generally not a problem except for the case of design staff which has the responsibility for the styling work. This has been done intentionally to minimize the engineering influence on the artistic slant of design. Aside from the liaison, none of these organizations are collocated with the platform. In the case of design staff, not even the liaison is collocated or exclusively assigned to one platform.

The system seems to work quite well for coordination, but the greatest weakness in the system is the lack of direct control that the program manager has over the assembly plant, the marketing organization, and most importantly the design staff.

Product Development Teams

The mechanism that allows the organizational structure described above to operate are a series of cross-functional product development teams. The primary team is the vehicle or platform level team, and it is chaired by the platform manager. The platform team has representation from each of the disciplines assigned to the platform manager as described above, as well as all the system chief engineers such as the chief body engineer. The primary function of this product development team is the coordination of vehicle issues and the resolution of issues that can not be resolved at lower level product development teams, as opposed to coordination of multi-platform
issues which is handled through the four phase process or coordination of components which is described later.

Each representative on the vehicle level team chairs a lower level product development team to coordinate information flow, and resolve issues in his functional area. For example, the chassis manager would chair a product development team to coordinate chassis area issues, and assign duties from the main product development team. In the case of the engineering area, there would be one additional level of product development team chaired by the release engineer. This team would coordinate system or product issues. Permanent representation on this lowest level product development team includes the development engineer, a purchasing representative, component engineers, supplier representatives, and an assembly plant representative. Also assigned to the team are individuals from all the various functions such as supplier quality, marketing, manufacturing, design staff, etc., but these representatives attend meetings only upon request. In contrast to the higher level product development teams, the chairman of this team is at the same organizational level as most of the other team members and carries no additional clout to resolve issues.

Although the functionality of the product development team process is difficult to comprehend and necessitates a great deal of time in meetings, product development teams make the coordination of tasks and designs much easier since the team members are forced to communicate, and the platform orientation focuses their efforts on one product. The employees build a rapport with the team and the vehicle. Issues that arise relating to coordination of design, financing, suppliers, etc. are easily resolved since the responsible individual is easily identified, and a working relationship already exists.

Meetings are no longer used only for coordination, but rather as a means of consensus building and decision making. With a product team, knowledge is shifted from knowing a little about a lot of different areas of a complex vehicle, to knowing a
lot about a small part of a complex vehicle, and knowing who holds the rest of the knowledge you need. An experienced General Motors engineer once said, "I don't know much about the car personally, but I know that within the corporation there is someone who knows exactly what I need to know - my only challenge is to find that person." The Product Development Team facilitates the connection of matching the people who need to know with the people who do know.

**Product Coordination**

As described above, there tends to be a great deal of coordination among personnel within a platform, but the coordination of common parts among different platforms is also crucial for cost effectiveness and the creation of a broad product portfolio at the lowest possible cost. The matrix organization described above indicates some inherent coordination through the functional hierarchy of the organization, but there is no direct emphasis for commonality at this level. More effective mechanisms for coordination come from corporate product teams involving functional engineers from each of the platforms. The most effective of these are the corporate committees chaired by the internal component divisions, particularly when the functional engineer is assigned to a platform but still reports to the division. Since executive incentives are based partially on divisional profits, it is in the best interest of the component divisions to force commonality of their parts and allow longer unit production runs, reduced cost, and increased divisional profits. The coordination of parts and systems is done through monthly corporate product development team meetings that all the functional release engineers attend at the component division sight location.

At this level, there is an apparent contradiction in the desires of the two entities involved. It is generally the platform that wants a unique part, while the component division strives for commonality. Unlike the case of product development teams within a platform, there is no "heavyweight" manager to drive consensus at these meetings. It
is only at the individual level where both sides try to assess the greatest benefit for the corporation that commonality is achieved, and it mirrors the dilemma between the functional manager and the project manager described earlier. In the case of outside suppliers, this component coordination mechanism does not exist, and it would be an interesting study to determine the component variety of parts for in-house supplied parts verses outside supplied parts.

In addition to the coordination of parts, the use of internal divisions effectively builds expertise in functional areas. In non-critical parts this is not so important, but in the case of components and systems that provide a competitive advantage, this is very crucial. One example is the Delco supplied Anti-Lock Braking system supplied on General Motors cars. This low cost system is possible due to the high volume achieved through a common system, and expertise that has been built on both the system side, and the vehicle integration side.

Current Developments

In January of 1993 General Motors announced the formation of a North American Operations Technical Center (NAO Technical Center). This NAO technical center divides the former technical staffs into three centers of expertise: a Vehicle Launch Center, a Divisional Support Center, and an Advanced Projects Center.62

The Vehicle Launch Center has been charged with initiating all new vehicle programs, and will carry new programs until the product strategy, product concept, and marketing concepts are completed.

The Divisional Support Center is intended to assist operating units with improving current products and manufacturing systems. "This will include product and

process development, prototype validation, creativity teams, problem solving, Proving Grounds testing, and several other NAO-wide technical functions".

The Advanced Projects Center is charged with conducting research and development for new technologies related to plants and products. This will include scientific studies and the conducting of experiments in solving problems. The center will propose solutions and create experimental hardware to test concepts.

The most fundamental change that the NAO technical center invokes, is in the formation of the Vehicle Launch Center. The Vehicle Launch Center alters the Four Phase process that General Motors has used to develop vehicles for over ten years. The Vehicle launch center will have responsibility for vehicle design through the end of phase zero and then pass the responsibility of engineering to the platforms. The Vehicle Launch Center is intended to reduce the work load through better coordination and focus, and through improving organizational learning since the launch center will hold the body of knowledge relating to vehicle development.63

The Vehicle Launch Center will be a collection of experts that the vehicle divisions will go to for engineering assistance.64 Once new vehicle ideas are approved by General Motor's strategy board, the Launch Center will discuss and determine basic characteristics of the vehicle. They will determine such characteristics as make, model, size, body style, powertrain, performance, fuel economy, ride and handling, equipment and price. Throughout phase zero, the launch center will make decisions on requirements, alternatives and direction of a concept, but the vehicle divisions will ultimately approve the design and the concept.65 An example of the changes to the current Four Phase process are depicted in figure 19 below.

63 Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on the road sooner," 22 February 1993, 3
64 Jack Keebler, "New GM system isn't all that simple," 23 November 1992, 3
65 Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on the road sooner," 22 February 1993, 3
The Vehicle Launch Center is housed in four separate 20,000 square foot floors at the Warren Technical Center. Each floor can accommodate one vehicle program at a time, so a total of four vehicle programs can be in the launch center at any given time. The plan is to form a cadence in the development of vehicles, and with the concentration of experts tightly focused on the development program, the programs will move much faster than under the old system.\textsuperscript{67}

This process is intended to leverage an advantage that General Motors has over every other automotive company in the world. According to Don Runkle, executive in

\textsuperscript{66} Jack Keebler, "New GM system isn't all that simple," 23 November 1992, 3
\textsuperscript{67} Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on the road sooner," 22 February 1993, 3
charge of the new launch center, "An advantage GM has over every other car maker in the world is we do more (new vehicle) programs than anybody. Because of the number we do, the launch center will allow our organizational learning to rise more rapidly than any other company could hope to match." 68

68 Al Fleming, "THINK BANK; Launch center's goal is to get GM designs on the road sooner," 22 February 1993, 3
VI. CONCLUSION

The current situation at General Motors involving inefficient plants producing cars that customers don’t want is a situation created by a management structure and product development organization of the past. The management of General Motors has recently changed, and one of the first actions of the new management has been the creation of a North American Operations strategy board, and a change to the product development organization. Just as the inefficiencies of today were created by the development process of the past, the development process of today will determine the efficiencies of General Motors of the future.

An analysis of the current efficiencies of General Motors that merely measures the efficiency of the plants can not be an accurate measurement of their competitiveness. In order to truly determine the competitiveness of a company, the metrics must include an analysis of the product development process. After all, it is the product development process that creates the products for the plants to build and determines the production process.

In analyzing the current situation of General Motor’s product development organization, it is evident that General Motors can modify its development process to leverage its strengths for the future. As the world’s largest corporation, General Motors can capitalize on economies of scale better than any other company, however, in order to do so, General Motors must resolve the dilemma of coordination and power, and the trade-off between commonization of parts and individual product identity.

General Motors rose to prominence through a sound product portfolio strategy that defined nameplate markets and shared common parts while maintaining product and nameplate identity. It appears as though General Motors has recognized the need to commonize vehicle platforms, but there is no evidence that the hierarchy of divisions
has been resolved. With the introduction of the Saturn and Geo vehicle lines, General Motors has only increased the complexity of establishing a divisional hierarchy. As in the 1920's, General Motors has too many vehicles in the same markets competing with each other and must establish a sound product portfolio strategy appropriate for today.

Beyond the product issues, General Motors must establish a strategy for the organization of personnel. Taking into account the organization of personnel in other successful automotive companies, the current movement of organizing people into teams is a step in the right direction. With the commonization of platforms, and the collocation of personnel representing all functional areas focusing on a single product, General Motors will be able to leverage its enormous engineering abilities. However, "An American project leader is [still] more apt to have a coordinating function, with product team members still reporting to department heads who control career paths."69 This imbalance of power must be altered.

In order to make product teams work at General Motors, the platform director must be given greater authority over the design staff, and a better relationship must be created with the marketing organizations. In the current matrix organization, there is not an effective hierarchy of power to resolve cross platform and cross organizational vehicle-related issues. Examples of the conflict that exists can be seen in a recent series of articles published in Automotive News regarding the structure of power at General Motors.

The article's author states that Edward Mertz, general manager of Buick, thinks of himself and his staff as the conductor when the Four Phase process relates to Buick. At the same time, Charles Jordan, vice president in charge of the GM design staff, says he and his staff are the conductors.70 Furthermore, even though design staff personnel

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69 Richard Johnson, "Toyota's one-man rule vs. GM’s dispersal of power," Automotive News, (2 March 1992), 34
70 Phil Frame, "'92 H-cars herald new era at GM; Four-Phase Process disperses decision-making powers," Automotive News, 3 June 1991, 1
are not the engine designers, nor the suspension or structure designers, Jordan believes that they should be the orchestrators of all the pieces. Jordan believes that the design staff should create the architecture of the car because the nameplate divisions do not know how to style cars. Reportedly, after the nameplates finished their work on a recent project, Jordan told them, "You guys go away; we'll show you what the image of a Buick is."  

The design staff designers see themselves as initiating the vehicle direction since they believe styling is the most important element of design. The attitude of Chuck Jordan is: "The divisions can't come down here and tell us what to do. They don't do that. They won't do that because I won't let them. If they don't trust the creative forces here, then they are going to miss out on some good stuff." General Motors must resolve the issue of who is in charge and what is most important to the customer by creating an environment of mutual cooperation. There must be a clear direction given to all the parties involved in the design process, and employees must be empowered and cooperate to carry out the directions. 

Historically the divisions have been very autonomous. There has been very little shared information between the nameplate divisions over the past few decades in an attempt to maintain separate brand images. According to Michael Losh, general manager of Oldsmobile, "Today I think our interests are best served by making sure everybody does know what is happening at the other divisions. So inadvertently, in trying to be different, things don't end up the same." 

Coordination is a key to resolving the dilemma of too many vehicles in the same markets. General Motors must establish a powerful and knowledgeable governing board to coordinate products and dictate this directive to the marketing organizations.

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71 Phil Frame, "'92 H-cars herald new era at GM; Four-Phase Process disperses decision-making powers," 3 June 1991, p1
73 Phil Frame, "'92 H-cars herald new era at GM; Four-Phase Process disperses decision-making powers," 3 June 1991, 1
and platforms. This board must decide how each division and product fits into a corporate product portfolio, not just in North America but also worldwide. It must determine the needs of the customers in all market segments and geographic locations, then establish vehicle direction and assign the engineering responsibility to a team for implementation. The board must determine the elements of the vehicle that must be differentiated according to the customers' needs, and define how they should be differentiated.

In the past, General Motors has been criticized for not listening to the customers or reacting to their needs. With the creation of product teams and the creation of a defined product portfolio strategy, it will finally be possible for General Motors to listen to the customers. Once the customers are defined through a product portfolio strategy and once the product teams are organized to work together, it is a manageable step to design vehicles according to customer needs, and provide customers with the product they want.

Finally, General Motors must resolve the issues regarding commonization of parts versus product identity. To resolve this issue, the governing board should dictate the areas of differentiation. All areas not designated as a differentiator according to customer needs should be designed to minimize corporate costs. General Motors should first replace the component divisions with an outside component sales organization solely created to sell components and vehicle systems outside General Motors. Functional areas should be created within General Motors headed by engineering managers with the same clout as the platform managers. Both the platform managers and the functional engineering managers should be responsible for implementing the direction of the governing board and report directly to the governing board. All functional design personnel below the chief engineer should be assigned on a "loan" basis to platforms and to the outside sales organization for the duration of a
project. Corporate personnel should be made responsible for evaluations and promotions upon the input of both the functional and project managers.

The Functional engineering manager would have partial responsibility for "shared" design engineers, and full responsibility for functional support design engineers and the manufacturing organization related to his functional area. The project managers would have partial responsibility for "shared" design engineers, and full responsibility for all aspects of the vehicle including the manufacture and the implementation of the governing boards direction for the styling and marketing of the vehicle. The current divisional and business support personnel should be eliminated, and both the functional and project managers' bonuses should be based primarily on corporate profits with a small percentage based on the performance of his responsible area.

The elimination of the business unit staff and the creation of a proper incentive package would eliminate the debate over the correct transfer price of components. The elimination of transfer pricing would allow the opportunity to redeploy internal sales and purchasing personnel to more value added tasks. Without the burden of divisional politics, and with the functional design engineers reporting to the functional engineering manager, the functional engineering manager could best coordinate the commonality of parts identified by the governing board as non-crucial product differentiators.

Additionally, with the elimination of the divisions it would be possible to create a corporate human resources department that would have the responsibility of educating and training all personnel. It would be possible to rotate personnel in order to educate them in all areas of the company or build functional expertise as the company required. Corporate personnel would have the responsibility for performance reviews and promotion with the active input from the functional and project managers. New engineers could begin with component responsibility and progress to greater
responsibilities allowing the company the opportunity to provide individual incentives other than just monetary increases and level promotions.
APPENDIX 1

1981 Through 1991 Sales Data

<table>
<thead>
<tr>
<th>Year</th>
<th>GM</th>
<th>Mid-Size</th>
<th>GM-10</th>
<th>Ford</th>
<th>Mid-Size</th>
<th>Taurus/Sable</th>
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NOTE: 1989 data estimated due to quality of microfilm.

74 Data compiled from 1982 through 1992 Automotive News Market Data Books, Automotive News. (From Microfilm)
# APPENDIX 2

## 1993 General Motors Product Line

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<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Platform</th>
<th>Base Price Range</th>
<th>Wheel base (in)</th>
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<tbody>
<tr>
<td>Chevrolet</td>
<td>Cavalier</td>
<td>J</td>
<td>$ 8,520 - $18,305</td>
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<tr>
<td></td>
<td>Corsica</td>
<td>L</td>
<td>$11,395</td>
<td>103.4</td>
</tr>
<tr>
<td></td>
<td>Beretta</td>
<td>L</td>
<td>$11,395 - $15,995</td>
<td>103.4</td>
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<tr>
<td></td>
<td>Lumina</td>
<td>W</td>
<td>$14,690 - $17,685</td>
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<td>Caprice</td>
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<td>$17,995 - $19,575</td>
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<td>Camaro</td>
<td>F</td>
<td>$12,180 - $20,815*</td>
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<tr>
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<td>Corvette</td>
<td>Y</td>
<td>$33,595 - $66,278</td>
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<td>Trucks</td>
<td>S-10 Pickup</td>
<td>S/T</td>
<td>$ 8,745 - $12,545</td>
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<td>S-10 Blazer</td>
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<td>K Blazer</td>
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<td>Sunbird</td>
<td>J</td>
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* 1991 Data
- Source:75, 76, 77

75 1993 General Motors Product Guide, General Motors Corporation, Detroit Michigan
76 Jack Keebler and Phil Frame, "GM sharpens platform ax; Nothing sacred in downsizing," Automotive News, (4 May 1992), 1
## APPENDIX 3

General Motors Platform Sales Volumes by model, 1981 through 1991

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Source\(^{78}\)

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## APPENDIX 4

### General Motors Group Sales

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