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REORGANIZING FOR MULTI-PROJECT MANAGEMENT:

TOYOTA'S NEW STRUCTURE OF PRODUCT DEVELOPMENT CENTERS

Kentaro Nobeoka

MITJP 96-11

Center for International Studies
Massachusetts Institute of Technology

E38-754
Center for International Studies
77 Massachusetts Avenue, Cambridge, MA 02139

Tel: 617-253-2839
Fax: 617-258-7432
Email: <robart@mit.edu>

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1. Introduction

The purpose of this paper is to discuss an emerging organizational structure for new product development at large Japanese automobile firms. This study specifically focuses on describing the objectives and outcomes of changes in product development organization implemented at Toyota in 1992 and 1993. This reorganization is the most fundamental change in product development organization that Toyota has implemented since it established the Shusa (product manager) organization around 1965. The new organization is aimed at multi-project management. It has three vehicle development centers in which multiple projects are grouped together, in contrast to either traditional single-project-oriented or function-oriented organizations.

Toyota has often been considered as a leader in adopting new organizational structures and managerial processes in both manufacturing and product development. For example, the Toyota production system, symbolized by its JIT and Kanban systems, has been targeted as one of the best practices in manufacturing by many firms, not only in automobiles but also in other industries. With respect to product development organization, Toyota led in establishing a project-based management system, which aimed at coordinating activities in different functional areas into a well-integrated new product. Clark and Fujimoto (1991) have described this as an organization featuring "heavyweight" product managers, who facilitate quick completion of a project by integrating different functions such as design engineering, manufacturing engineering, and marketing. An MIT research project, the International Motor Vehicle Program, referred to this approach as "lean product development" (Womack et al., 1990).

In addition to the efficient development of individual products, many studies have shown that Toyota and other Japanese leading automobile firms have been developing new products to add new product lines or replace existing products more frequently than U.S. or European competitors (Abegglen and Stalk, 1985; Womack et

al., 1990). Their capability in developing individual products efficiently through a project-oriented organization helped implement the strategy of prolific product introductions. This frequency has been overwhelming to some Western firms and has been considered as one of the sources of Japanese firms' competitive advantages in world markets (Fujimoto and Sheriff, 1989, Nobeoka and Cusumano, 1994). In the past 15 years, for example, the number of passenger vehicle lines including sports utility models at Toyota has more than doubled, rising from 8 to 18. Toyota also has maintained its four-year product life cycles for most of its product lines, which is much shorter than those in the Western firms.

In recent years, however, all Japanese manufacturers, including Toyota, have become more concerned with efficiency in developing new products. In most of their major markets, demand has slowed or even declined, while the cost competitiveness of Japanese firms has considerably decreased because of the appreciation of the yen and improvements at Western competitors. They have been facing profitability problems that are related at least in part to the high costs of developing and manufacturing so many new products or product variations. Therefore, Japanese firms are trying to develop new products more efficiently while maintaining both a high frequency of new product introductions and high design quality in individual projects.

In the highly competitive environment of the 1990s and the foreseeable future, therefore, successful companies need to optimize not just one project at a time but a portfolio of projects and technologies. In order to achieve economies of scale and scope in product development as well as manufacturing, it is common for firms to leverage their financial and engineering resource investments by reusing existing technologies and designs in multiple projects. Firms also have to consider how to share many components among multiple products without sacrificing an individual product's design quality and distinctiveness. A key challenge to managers of product development is to share technology across multiple product lines and across multiple generations of products without overly compromising design quality and competitiveness.

A project management system that assigns too much autonomy to each product manager may concentrate too heavily on developing multiple new products through relatively autonomous project-oriented organizations. This system tends to result in the development of many proprietary components for each project, and may require excessive financial and engineering resources. Therefore, automobile manufacturers may need a product development organization that better balances individual project performance with inter-project coordination. For example, Chrysler's project-team approach, used for the LH and Neon projects, might only be appropriate for optimizing the development of one product at a time. In contrast, Toyota managers have considered that a project-team approach is not an efficient way for large firms to develop many products concurrently that could share similar technologies and components.

Firms that try to optimize the management of multiple projects simultaneously need an organization that is suitable for coordinating inter-project interfaces and interdependencies. Because most product-management research has focused on the management of single projects, this is not helpful for managers and researchers to understand the complexity of coordinating multiple projects. It may seem that a traditional function-oriented, rather than project-oriented, organization is appropriate to manage inter-project interdependencies. However, this type of structure is weak at cross-functional integration. Functional organizations also lack a mechanism to ensure that individual products retain distinctive features and a high degree of what has been called "product integrity." Therefore, organizations should aim at achieving both cross-functional coordination and inter-project coordination simultaneously through the way they organize and control multiple projects. This goal cannot be achieved by either traditional project-oriented or function-oriented organizations. The inter-project interdependencies must be coordinated within the context of a specific project as an integrated system. To share components while retaining the distinctiveness of individual products, firms also need organizational

structures and processes that enable system-level coordination across multiple projects.

Toyota's reorganization into product development centers represents one way to manage multiple projects. By establishing three centers, each of which contains several vehicle development projects, Toyota has improved inter-project coordination among technically related projects. At the same time, Toyota has strengthened the authority of project managers over functional managers, and this has improved cross-functional integration. These two goals may sound contradictory, but this paper focuses on how Toyota has solved this contradiction. This paper is based on interviews with three general managers, four product managers, fifteen engineers, and three cost management planners between 1992 and 1994.

2. Problems of the Traditional Shusa Organization at Toyota

In 1953, Toyota assigned the first shusa, or product manager, to a new vehicle project (Ikari, 1985)[1]. When Toyota started product development for the 1955 Crown, Kenya Nakamura became the first shusa to head a project. At that time he was a member of the Engineering Management Division. The shusa organization was strengthened in February 1965 when Toyota formally established the Product Planning Division to organize and support shusas. At that time, there were already ten shusas[2], and each shusa had five or six staff members, which totaled about 50 members in the division. The basic organizational structure with respect to the roles of the Product Planning Division and shusas did not fundamentally change until 1992, when Toyota introduced the center organization. One of the minor changes before that time was a change in the title name for a product manager from "shusa" to "chief Engineer" in 1989. In order to avoid any confusion, the rest of this paper will

[1] I referred to this Ikari's book with respect to the information regarding the early period of the Shusa organization in the 1950's and 1960's.

[2] Each of the ten shusas were responsible for Crown, Mark II, Publica, Century, Celica/Carina, Toyota 2000 GT, Corona, Corolla/Sprinter, Toyoace, Miniace.

consistently use the new term, chief engineer, to refer to this position, rather than shusa or product manager.

After having maintained the same basic structure for more than two decades, in 1990, Toyota decided to evaluate its entire product and technology development organization and to change it if necessary, so that the organization would fit the competitive environment at the end of the twentieth century. Toyota launched an initiative, called the Future Project 21 (FP21), to study any problems in its product development organizational structure and processes. The leader of the project was Yoshiro Kinbara, an executive vice president in charge of product and technology development. A manager at Toyota explained that no specific threats triggered this project. At that time, Toyota was actually doing better than most of its competitors. People at Toyota, however, recognized that organizations sometimes needed to be reviewed and overhauled to continue to be competitive in a changing environment. A consulting firm[3] was hired for this project evaluated the organization performance at Toyota as a starting point of the FP21.

Soon after the FP21 started its studies, the team identified two important problems. These problems led Toyota to conclude that it would need a major reorganization. First, there was an organizational problem. A primary point was that Toyota's product development organization had become less efficient in communication and had come to need more coordination tasks than before to manage new product development. Second, the competitive environment for the Japanese automobile industry started changing drastically around 1990, which seemed to require Toyota to change its product development strategy and organization. Due to various factors such as the appreciation of the yen, the Japanese auto industry faced decreasing competitive advantages against most competitors in the world. The following sections discuss these two problems in more detail.

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[3] Toyota chose the Nomura Research Institute, a Japanese consulting firm rather than prestigious U.S. based firms such as McKinsey. A person at Toyota mentioned three reasons for this decision: (1) A Japanese consulting firm may know more about Japanese firms. (2) Toyota wanted plans for implementations, rather than grand strategies. And (3) a Japanese consulting firm seemed likely to

Organizational Problems

Figure 1 shows Toyota's product development organization before its reorganization in 1992. There were, at that time, as many as sixteen design engineering functional divisions, and each had a functional manager. There were about fifteen projects proceeding concurrently, even though Figure 1, a simplified model, depicts only nine projects. Each project had a chief engineer, who was located in the Product Planning Division under a general manager.

The product development organization was actually a huge matrix organization rather than a project-based organization. Chief engineers and general managers in the Product Planning Division did not directly oversee the engineering divisions in this organization structure. However, chief engineers at Toyota were supposed to have considerable authority over the entire product development process, including different engineering stages, manufacturing, and product concept creation. According to the definition by Clark and Fujimoto (1991), chief engineers at Toyota were supposed to be typical examples of "heavyweight" product managers.

However, in reality, the product development organization at Toyota had become much larger than before, and chief engineers started to find it difficult to control and integrate different functional divisions when making a new product. As the number of product development projects increased, the number of engineers also increased. At the same time, the degree of specialization in the engineering divisions had become narrower, reflecting the increasing number of different engineering divisions. As of December 1991, there were about 7000 people in the sixteen product development engineering divisions. They were working, on average, on fifteen concurrent projects. In addition, Toyota had a Research and Advanced Development Group located at the Higashi-Fuji Technical Center. This had about 2000 additional people[4].

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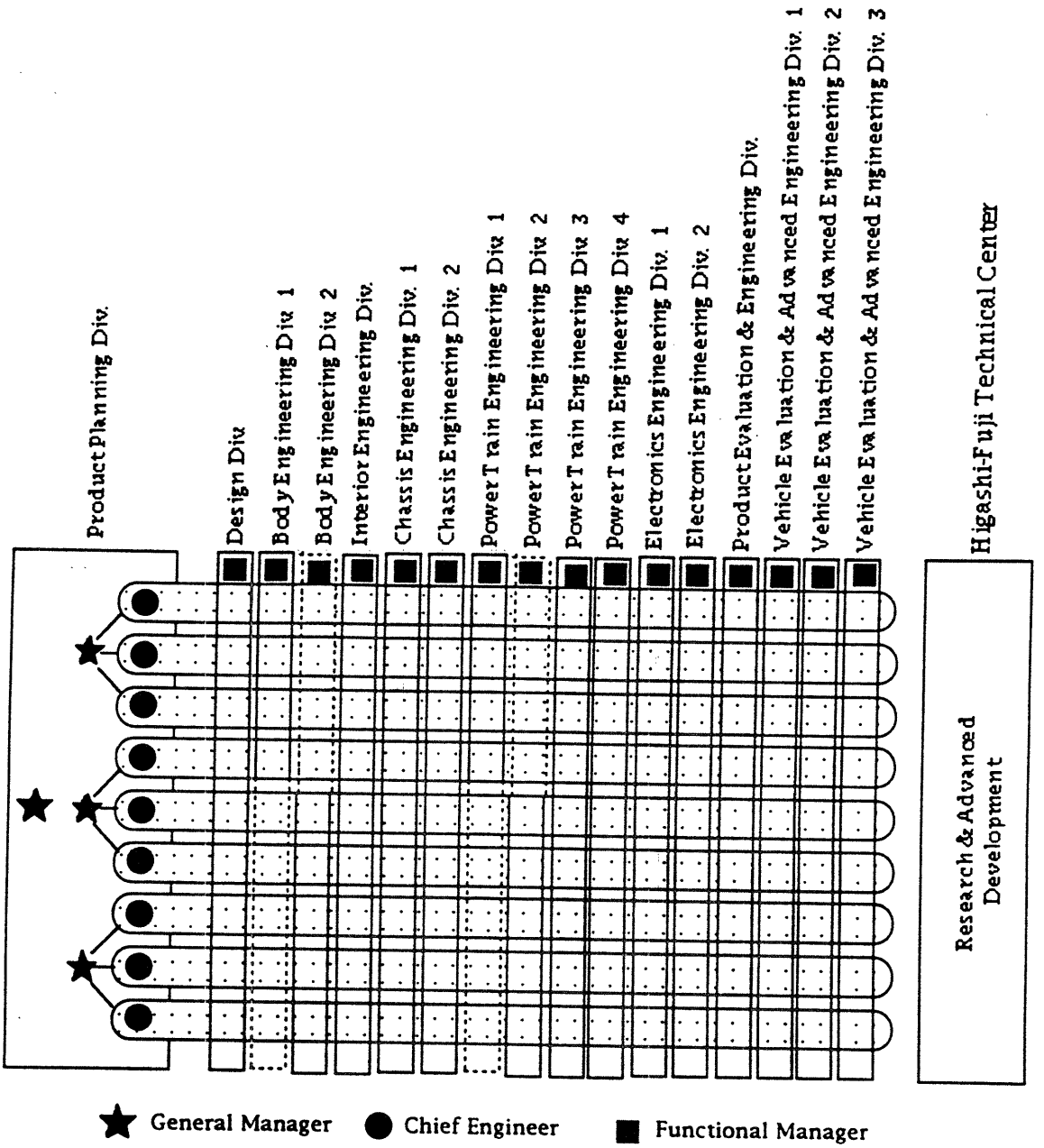
provide more value per cost than a U.S. firm.

[4] 7000 people in the sixteen engineering divisions and 2000 people in the RAD group added up to

Figure 1 Toyota's Product Development Organization in 1991



In 1991, a chief engineer had to coordinate people in 48 departments in 12 divisions to manage new product development. This estimate comes from Toyota's internal data on the number of frequent participants in meetings a product manager

9000. There were, in total, about 11,500 people working on product development. The rest of the people were engaged in supporting activities such as patent management, certification process management, CAD system development, and prototype development.

held[5]. In 1976, there were only 5000 people in the entire product development organization. A chief engineer had to coordinate only 23 departments in six divisions. At that time, a chief engineer generally needed to talk with only six division managers to integrate all the design engineering functions. This change indicated that, during the fifteen years, coordination tasks had become much more complicated for chief engineers.

In addition to this added complexity, there was another problem that made it difficult for some chief engineers to manage a new product development project. Some relatively junior chief engineers started to complain that they did not always have enough authority over senior functional managers. Originally, only a limited number of "charismatic" senior managers tended to rise to the position of chief engineer. Toyota people often considered them as "gods" within their projects. However, in recent years, Toyota has assigned relatively junior people to the position of chief engineer. There are two reasons for this change. First, the number of chief engineers required to cover all new vehicle projects had increased. Second, Toyota recognized that people needed particular talents to be excellent chief engineers, and their seniority was not as important as their ability.

Functional managers also found it difficult to spend sufficient time on managing engineering details of all the vehicle projects, because most managers had to oversee about fifteen different projects[6]. They did not have enough time to oversee complicated interfaces and interdependencies between these projects either. Due to the large number of functional divisions and vehicle projects, each chief engineer was able to arrange for regular meetings with all the relevant functional managers only about once every two months.

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[5] Even though there were sixteen design engineering divisions, a chief engineer for a particular project did not necessarily need to manage all of these. These data were based on Toyota's internal measurements. The Company did not explain in detail its methodology for the measurements.

[6] There were a few exceptions. For example, as of 1991, there were already two separate body engineering divisions, each of which was responsible for front-wheel-drive and rear-wheel-drive vehicles, respectively. Therefore, each functional manager was in charge of about a half of the entire vehicle projects.

There was a problem also at the engineering level. Because of their narrow specialization, engineers did not have a "system view" of the entire product. For example, some engineers only knew about the inner body of doors and did not know much about the outer body because interior engineering and body engineering divisions were separate. This kind of excessively narrow specialization had a negative impact on the development of a well-integrated product. In addition, Toyota realized that the narrow specialization caused another problem for engineers when they were promoted to become a manager in charge of a larger engineering task such as the entire body. It was difficult to train general engineering managers in this organizational structure.

Engineers also found it difficult to have a strong sense of commitment to a specific vehicle development. Because of the narrow specialization and the large number of projects, each engineer frequently had to transfer between unrelated vehicle projects. This may sound useful to transfer technical knowhow between different projects. In reality, however, despite the frequent transfer of engineers, Toyota found that it could not transfer system knowledge in this way. Nor was this structure particularly appropriate for inter-project knowledge transfer.

Toyota's rapid growth in size partially caused these organizational problems. One way to increase the chief engineer's authority and to eliminate problems caused by narrow specialization is to create a pure project team organization, such as Chrysler adopted for its Neon project. In this organization, almost all engineers exclusively work for a single project for its entire duration. However, Toyota did not consider the project team organization efficient. This type of organization can work well for firms with a small number of projects and little technical interdependency between multiple products concurrently being developed. Because Toyota has many projects and a limited number of engineers, it cannot assign engineers to a specific project for the entire duration of the project. The peak period for design engineering work for engineers in a specific project lasts only about one and half or two years out of a four-year project. Therefore, when a project task is outside of the peak, engineers

should be transferred to other projects to be utilized efficiently. In addition, a change in the competitive environment discussed in the next section also made the project team approach inappropriate. In the new environment, effective inter-project technology sharing has become more important.

Even the organization at Toyota prior to 1991 had problems with respect to inter-project coordination. One of the policies of Toyota's chief engineer organization was to encourage the autonomy of each chief engineer with respect to his own vehicle project. General managers in the Product Planning Division above chief engineers, therefore, did not supervise chief engineers in the details of individual projects. In addition, the number of vehicle projects was too large for managers to deal effectively with multi-project management issues such as resource allocation, technology transfer, and component sharing across all projects.

Finally, there was a problem regarding coordination with the Research and Advanced Development (RAD) Group located at the Higashi-Fuji Technical Center[7]. The center was maintained relatively independent of specific vehicle development projects, so that it could focus on research and advanced engineering. However, both vehicle projects and the RAD group were dissatisfied with this organizational structure. Engineers for specific vehicle projects did not think that the RAD group developed technologies that could be useful for their projects. On the other hand, engineers in the RAD group felt frustrated because vehicle projects did not use technologies that they developed. Toyota reached a conclusion that these two groups needed more integration organizationally.

In summary, Toyota's product development organization had five problems. These caused difficulties in both project integration and inter-project coordination:

1. There were too many functional engineering divisions with too narrow specialization of engineers.

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[7] Because Research & Advanced Development Group was mainly located in the Higashi-Fuji Technical Center, these two names are often interchangeably used. Higashi-Fuji is located about 150 miles east of Toyota's headquarters, which contains the primary functions for product development. This paper uses a shorter name, RAD group, which is original here and is not used at Toyota.

2. There were too many vehicle projects for each functional manager to manage the engineering details of each project as well as inter-project coordination.
3. It had become much more complicated and difficult for chief engineers to oversee all the engineering functions.
4. The chief engineer organization was not appropriate for inter-project coordination.
5. The RAD group and vehicle projects were not sufficiently coordinated.

Change in the Competitive Environment

The competitive environment surrounding Japanese automobile firms started changing around 1991. There were two interrelated issues. First, rapid growth in production levels at the Japanese firms virtually ended. The aggressive product strategy of Japanese automobile firms in the 1980's, such as frequent new product introductions and replacements, had been partially based on their assumption of continuous rapid growth. The new environment seemed to require some changes in this strategy, as well as in company organizations. Second, the importance of cost reduction became even more critical for international competition than before. In addition to the appreciation of the yen, Japanese advantages in development and manufacturing productivity have been diminishing. Both factors have had a strong negative impact on the cost advantages they had been enjoying.

Because of these changes, the traditional chief engineer system, which primarily focused on building the best individual products one at a time, needed to be revised. Chief engineers always thought about the success of only their own projects. A general manager who used to be a chief engineer said, "Each product manager wanted to increase sales of his own project even by developing many new proprietary components and by expanding the target customer segments of his project into other product lines within Toyota." He explained that, during the period when Toyota's production volume was growing rapidly, these characteristics of Toyota's chief engineer system worked well for the Company. Because total production was growing rapidly, cannibalization of individual product lines was not a major problem. The

market in each product segment also expanded, and this growth made it possible for each project to expand its target market.

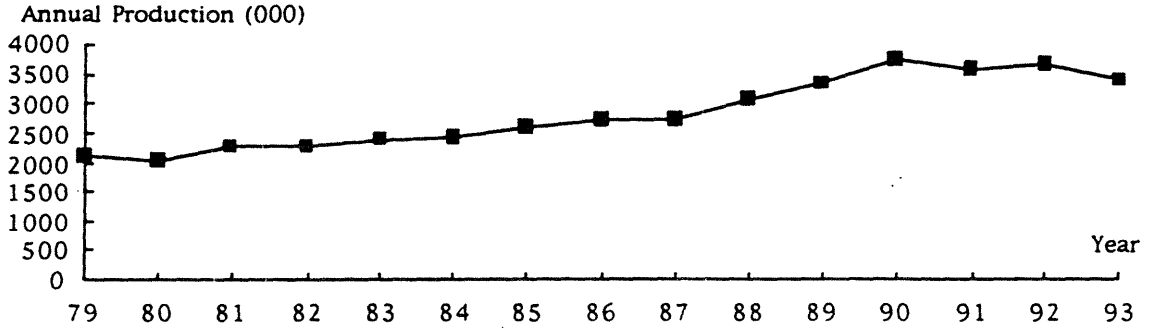
In addition, Toyota was able to sell more of most new products than it had expected. Therefore, high development and production costs caused by many new proprietary components was not much of a problem either. A manager in charge of cost management admitted that, "Prior to 1991, few new products met an original target cost when it was introduced to the market. However, the sales volume for each new product was usually larger than its original plan. The large sales volume lowered the actual production cost compared to its original plan through scale economies. In the end, a new product usually reached the production cost that had been originally planned, when the entire production during its life cycle was fully considered." Because of a faster depreciation of manufacturing equipment than original plans, production costs also appeared to be lower than expected. Given this common pattern, a chief engineer primarily tried to develop a new product that would sell well, rather than a product that would meet a conservative cost target.

However, starting in 1990, Toyota's production volume stopped growing and even started declining, as shown in Figure 2. Profit from each new product also started decreasing. Under these circumstances, Toyota needed a new product development strategy and organization, particularly with respect to cost management. One particular aspect of the chief engineer system was considered inappropriate in this new environment: The management of each individual project was too independent. Toyota concluded that multiple related projects needed more coordination.

First, in the stagnant market, new products should be more carefully positioned to each other so that any cannibalization would not occur. Within a limited total sales volume, the expansion strategy of one product line would easily cannibalize some portion of sales of neighboring products within Toyota. Second, in order to reduce production cost, Toyota needed to increase in commonalty of components and technologies among multiple new products. Sales increase, which used to help cover

shortage in cost reduction efforts, could not be expected anymore. Under the Toyota's chief engineer system, there was a tendency that each project overly developed its proprietary components. There are many symptoms of the old product strategy and organization at Toyota. For example, there are now three distinctive platforms for three products that are similar in size and technology: the Corona/Carina, the Celica/Carina ED, and the Camry. A chief engineer for each project wanted to develop an ideal platform for each product.

Figure 2 Production Units at Toyota



Source: Automotive Yearbook 1994

In view of these organizational problems and changes in the competitive environmental, Toyota decided to change its product development organization rather extensively. A new organization needed both to strengthen the integration mechanisms for engineers in different functions so that they could create a well-integrated new product, as well as to facilitate coordination among different projects so that technologies and components can be effectively transferred and shared. These two objectives are in a sense contradictory, because Toyota needed both to strengthen its project orientation as opposed to function orientation, and to enhance inter-project coordination. For example, a project-oriented team approach might be appropriate for a strong project orientation, but might be inappropriate for inter-project coordination. On the other hand, strengthening the functional orientation to enhance the efficient usage of specific components throughout multiple vehicle

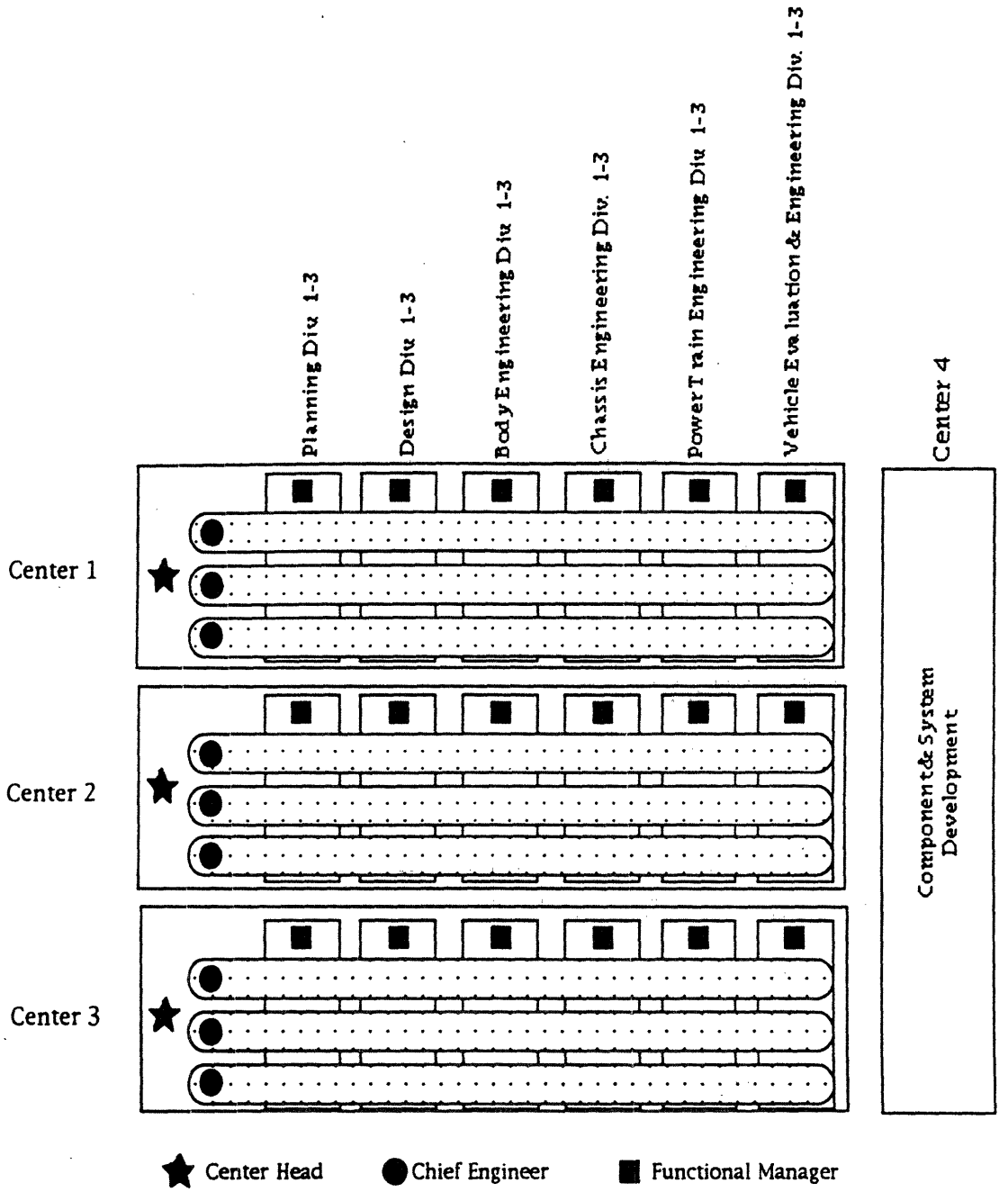
projects would be totally unsuitable to enhance an individual product's level of integration or coherence. Therefore, these two problems cannot be solved simply by these two alternatives. Thus, Toyota reached a conclusion that it would fundamentally change its organizational structure for product development.

3. Establishment of Development Centers

Toyota made two major changes in its product development organization. These changes did not reduce the total number of people working on product development at Toyota. At the end of 1991 before the reorganization, there were about 11,500 people in product development, and the number rose to about 12000 in 1993. Rather the changes specifically targeted the problems discussed in the previous section.

First, in 1992, Toyota divided all of its new product development projects into three centers as shown in Figure 3. The center grouping focuses on the similarity in platform design. Center 1 is responsible for rear-wheel-drive platforms and vehicles, Center 2 for front-wheel-drive platforms and vehicles, and Center 3 for utility vehicle/van platforms and vehicles. Each center has between 1500 and 1900 people, and works on about five different new vehicle projects simultaneously. Toyota had considered other grouping schemes, such as by product segment (luxury vs. economical vs. sporty cars, or small vs. medium vs. large cars). Toyota chose platform design similarity because this would lead to the highest level of inter-project design interdependencies within a center. In addition, because new platform development requires the most resources, sharing a platform design among multiple product lines would save the most in engineering investment and reduce production costs most effectively.

Figure 3 Toyota's Product Development Organization as of 1992



Second, in 1993, Toyota created Center 4 to develop components and systems for all vehicle projects. It reorganized the Research and Advanced Development Group (the RAD Group), and assigned most people from this to Center 4. While the RAD Group used to work on research and advanced development rather independently, Center 4

closely supports vehicle development by providing specific projects with components and systems. In addition to engineers in the RAD group, Center 4 added engineers working on some components such as electronics and new engines that did not need much daily coordination with a vehicle project.

As discussed earlier, the center organization changes were supposed to improve both project integration and inter-project coordination. This section specifically describes how some key aspects of the reorganization related to improvement in these two areas. Important features of this reorganization include:

(1) Reduction of the number of functional engineering divisions.
(2) Reduction of the number of projects for each functional manager.
(3) Changes in the roles of the center head for multiple vehicle projects.
(4) Establishment of planning divisions in each center.
(5) Adoption of a hierarchical organization for chief engineers in related projects.
(6) The roles of Center 4.

(1) Reduction of Functional Engineering Divisions

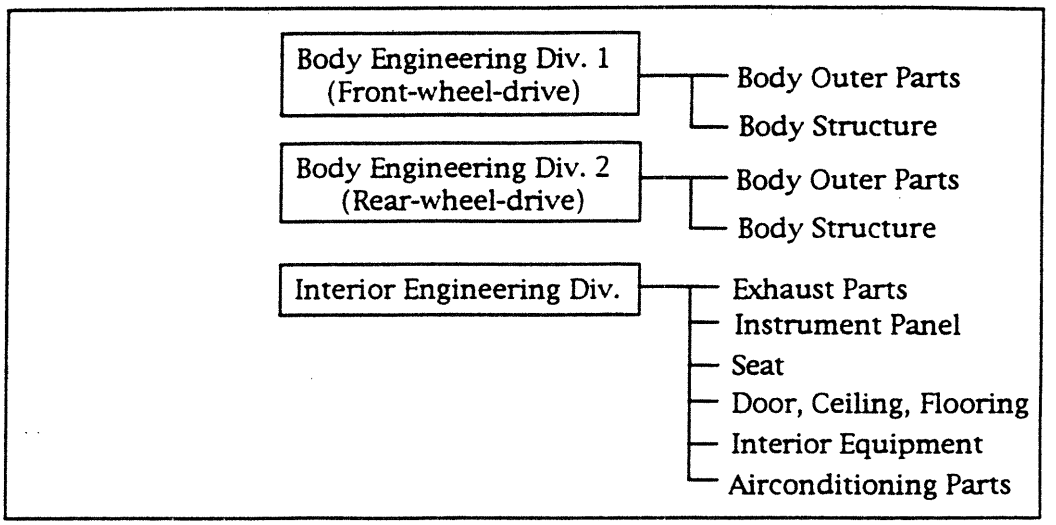
In order to decrease coordination tasks required for a well-integrated vehicle project, Toyota reduced the number of functional divisions for design engineering. The complexity raised by the large number of functional divisions made it difficult for chief engineers to manage vehicle projects. While the old organization had sixteen different functional divisions, each new center has only six engineering divisions.

This simplification into the center organization prompted two other changes. First, specialization in each functional engineering division widened. For example, as shown in Figure 4, Toyota used to have two separate divisions for designing bodies and interior/exterior equipment: the Interior Engineering Division and the Body Engineering Division. In the new organization, the Interior Engineering Division merged with the Body Engineering Division. Another example is the merger of two different chassis engineering divisions, each of which had been separately responsible for suspension systems and brakes. Each design engineering division now has wider design responsibilities. An important point is that this did not enlarge

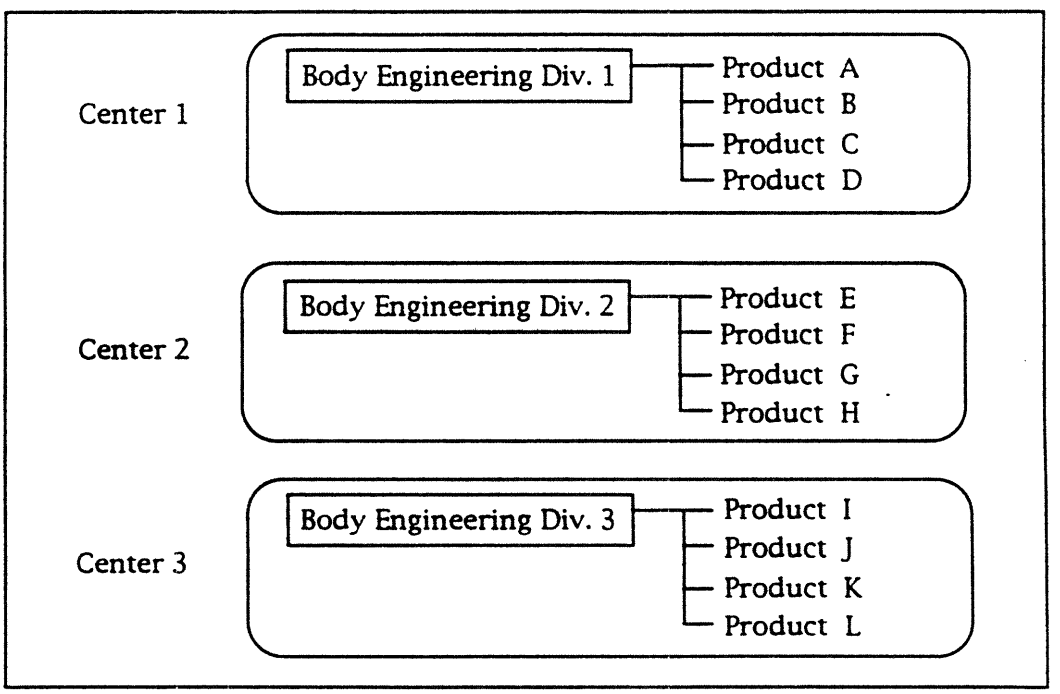
the size of each functional division, because each functional division is now responsible for only a limited number of projects within the center.

Figure 4 Old and New Organizations for the Body Engineering Function

Old Organization (1991)



New Center Organization (1992)



Second, Toyota also reduced the number of functional divisions to be managed in a specific vehicle project through the usage of Center 4, the component and system

development center. In order to simplify the work of the first three centers, Toyota separated development of some components and systems that can be managed outside specific vehicle projects. Toyota considered three factors to decide whether particular engineering functions should be in a vehicle project or the component center. First, managers decided that components that need to be extensively tailored to each vehicle project should be managed within a project. Second, components that have to be carefully coordinated with other parts of the vehicle design should also be developed within the project. On the other hand, some components with modular characteristics can be developed separately from specific vehicle projects and still be inserted into a product design relatively easily. These may be developed in Center 4. These types of components and systems tend to be shared by multiple vehicle projects, and it is not efficient to develop them in a specific project. Third, component development that needs much new technical knowledge should be developed in Center 4. Such development usually requires a group of technical specialists working together. These types of components also sometimes need a long time to develop and do not fit the time frame of specific vehicle projects.

Following these guidelines, Toyota allocated the development of some components or systems to Center 4. For example, the upper-body design directly visible to the customer has to be differentiated in each product. It should also be extensively interdependent with other parts of the automobile design, such as the chassis and interior. Therefore, the upper-body design should be managed within the project, and Toyota maintained this function within Centers 1-3. On the other hand, components like batteries, audio systems, and air conditioners do not usually need to be tailored to each different vehicle project. Therefore, Toyota moved the Electronics Engineering Divisions that developed these electronic components to Center 4.

The example of the Electronics Engineering Divisions is actually more complicated and indicates the extensive thought and analysis that Toyota put into implementing this reorganization. Toyota carefully examined characteristics and interdependencies of each component development, so that Centers 1-3 can be

simplified and yet contain all relevant components that need extensive coordination within each vehicle project. For example, among the electronics components, the wire harness usually needs to be tailored to each vehicle project and has considerable interdependency with the body structure. Therefore, Toyota merged this engineering function into the Body Engineering Divisions and kept wire harness development within Centers 1-3.

Another example of eliminating activities from the vehicle project centers is the development of totally new engines, which is now located in Center 4. There are many engineering tasks involved in new engine development that are not related to integration tasks within a particular vehicle project. In addition, the time frame of new engine development does not fit that of specific vehicle projects. New engines usually need about six to eight years to develop, which is longer than the 4-year lead time of the average new vehicle project.

In this way, only component engineering that needs extensive project integration remains in the vehicle project centers. In the old organization, part of the product development organization was responsible for both vehicle projects and most component development. This mixture made the old organization complicated and difficult to manage.

In summary, by widening the engineering specialization within each division and by transferring some component development into Center 4, Toyota limited the number of functional divisions in Centers 1-3. In addition, because Toyota divided each function only among three centers, the wider specialization did not require larger functional divisions.

(2) Reduction of the Number of Projects for Each Functional Manager

Each functional manager is responsible for a smaller number of projects in the new center organization. For example, managers in Center 1 can focus only on vehicle projects with rear-wheel-drive platforms. Because, in some functional areas, there used to be too many projects for functional managers to oversee, it was difficult

for them to pay careful attention to all the projects. For example, as shown in Figure 4, the functional manager for interior engineering was responsible for all different vehicle projects, which usually added up to about 15 concurrent projects. In the center organization, all functional managers are responsible for only about five product lines that are all technologically related to each other. Each functional manager now can spend sufficient time on the coordination with each chief engineer. In addition, this reduction of the management scope for each functional manager should result in more effective multi-project management in such areas as resource allocation and technology sharing. Each functional division can also focus on fewer types of vehicle technologies. This focus may lead to more efficient development and accumulation of technical knowledge as a division.

(3) Roles of the Center Head for Multiple Vehicle Projects

Each head of Centers 1-3 officially supervises the entire product development operations, including both chief engineers and design engineering functions within the center. Equivalents to the center heads in the old organization were three deputy general managers above chief engineers in the Product Planning Division. Each of the deputy general managers was in charge of small cars, large cars, and trucks/vans. They reported to the general manager of the Product Planning Division. However, they officially managed only chief engineers, not functional managers and engineers as seen earlier in Figure 1. These general managers above the chief engineers, therefore, were not supposed to manage design engineering in detail. In addition, there were also general managers above the functional managers, and it was not often clear which general managers - those above chief engineers or those above functional managers - had more authority. In the center organization, each of the three center heads manages engineering details for multiple vehicle projects within the center. From these perspectives, while the old organization was officially a matrix organization both at the chief engineer level and at the general manager level, the new one is organized primarily around projects.

Using their positions, the center heads are supposed to play two important roles that have to be deliberately balanced. First, a center head helps each chief engineer integrate different functions. One of the key elements of the Toyota chief engineer system has been the strong leadership of a chief engineer. However, as discussed earlier, chief engineers recently found some difficulties in coordinating all the functional managers. In the center organization, chief engineers can use the center head's support to manage different functions. Second, each center head is responsible for the coordination of different vehicle projects within the center. A center head can now effectively implement this because he manages all the operations in the center. The separate planning division in each center, discussed next, also helps the center head coordinate projects.

(4) Establishment of Planning Divisions in Each Center

Each center has a planning division to support the management of each center. The Planning Division consists of staff members and three departments: the administration department, the cost planning department, and the product audit department. There are about 170 to 200 people in each planning division of the three centers. The administration department is responsible for personnel management, resource allocation, and the long-term product portfolio planning within each center. It also conducts an advanced concept study for individual projects, before these projects become a formal project and a chief engineer is assigned.

The equivalent of the Planning Divisions in the old organization was the Product Planning Division. One of the major structural differences is that chief engineers used to be located within the Product Planning Division. Most members in the Product Planning Division directly worked for individual chief engineers. For example, most cost management people in the division used to be divided by vehicle project and primarily reported to individual chief engineers. On the other hand, in the new organization, cost management people are more independent of chief engineers and report to the planning division manager and the center head in each

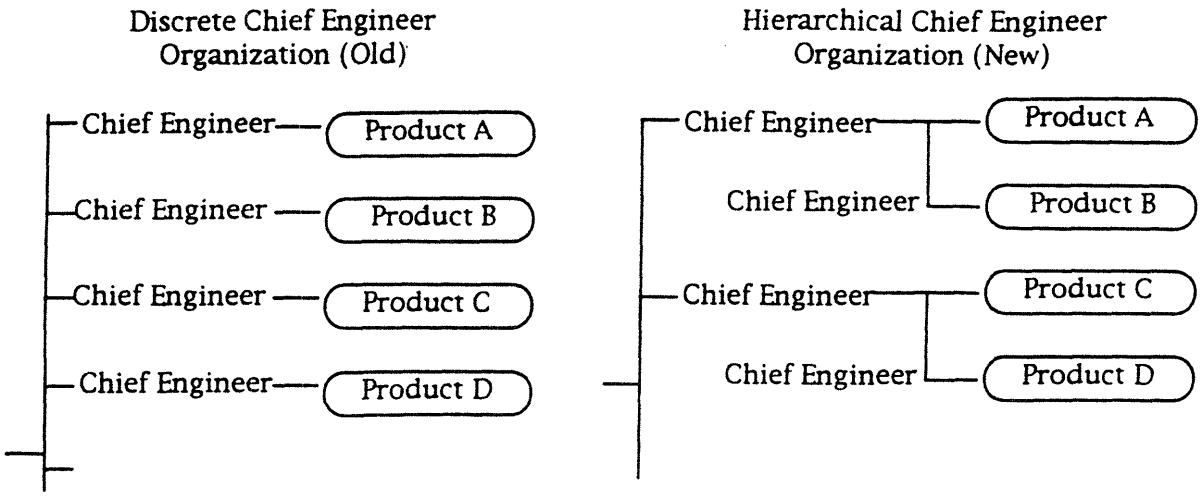
center, although they continue to work closely with chief managers. This reflects one of the central concerns at Toyota, which is that each center needs to reduce development and product costs by efficiently leveraging resources and components across multiple projects.

Each center also does long-term product portfolio planning. The management scope used to be so large in the old organization that the project portfolio planning and resource allocation for each project were too complicated to be effectively managed. Now the Planning Division in each center can consider technology sharing and resource allocation among multiple projects in the present and the future more carefully than before, by focusing on a limited number of closely related projects. This type of center-oriented management support may be critically important to the effective operation of the center organization.

(5) Hierarchical Organization of Chief Engineers

Another feature in the center organization is the hierarchical chief engineer structure for managing product families as shown in Figure 5. This structure also helps strengthen the multi-project perspective of the center organization. For example, there used to be two separate chief engineers for the LS 300 and the Supra projects. Now, there continue to be two chief engineers, but one of the two supervises both the LS 300 and the Supra projects, and primarily manages the LS 300 project. The other chief engineer manages the Supra project and reports to the chief engineer of the LS 300. Toyota also made the same kind of change for another pair of projects: the Tercel and the Starlet. Although this type of structure is not adopted for all projects, Toyota appears to be moving the organization in this direction.

Figure 5 Hierarchical Chief Engineer Organization for Multi-Project Management



Each of these pairs of projects share almost identical platform and drive train designs, even though these two projects target completely different customer segments and have separate product concepts. For example, the LS 300 is a luxury personal car and the Supra is a sports car. Therefore, it is important to manage the two projects separately, so that each project develops a product that fits with its own customer needs. A planning division manger at Toyota says that it is difficult for a single chief engineer to develop two products with widely separate concepts and to give the same level of commitment to each of these. However, at the same time, because these two projects should share the same platform design, they need extensive coordination. Therefore, the projects have to achieve differentiation in product characteristics and integration in product development at the same time. The hierarchical chief engineer organization is one way to pursue these two goals simultaneously.

(6) Roles of Center 4

As explained earlier, Toyota based Center 4 primarily on the RAD group in the old organization. As shown in Figure 6, the basic structure of the organization and technical areas has not significantly changed. Technical areas of both the old and

new organizations include vehicle (body and chassis), engine and drive train, electronics, and materials. The most important aspect of the change was that, while Center 4 focuses on developing components and systems for vehicle projects, the RAD Group was relatively research-oriented. The relationship between the RAD group and vehicle projects was that between upstream and downstream organizations. Center 4 has virtually become a part of the vehicle development organization, and is responsible for system components that could be better developed outside specific vehicle projects.

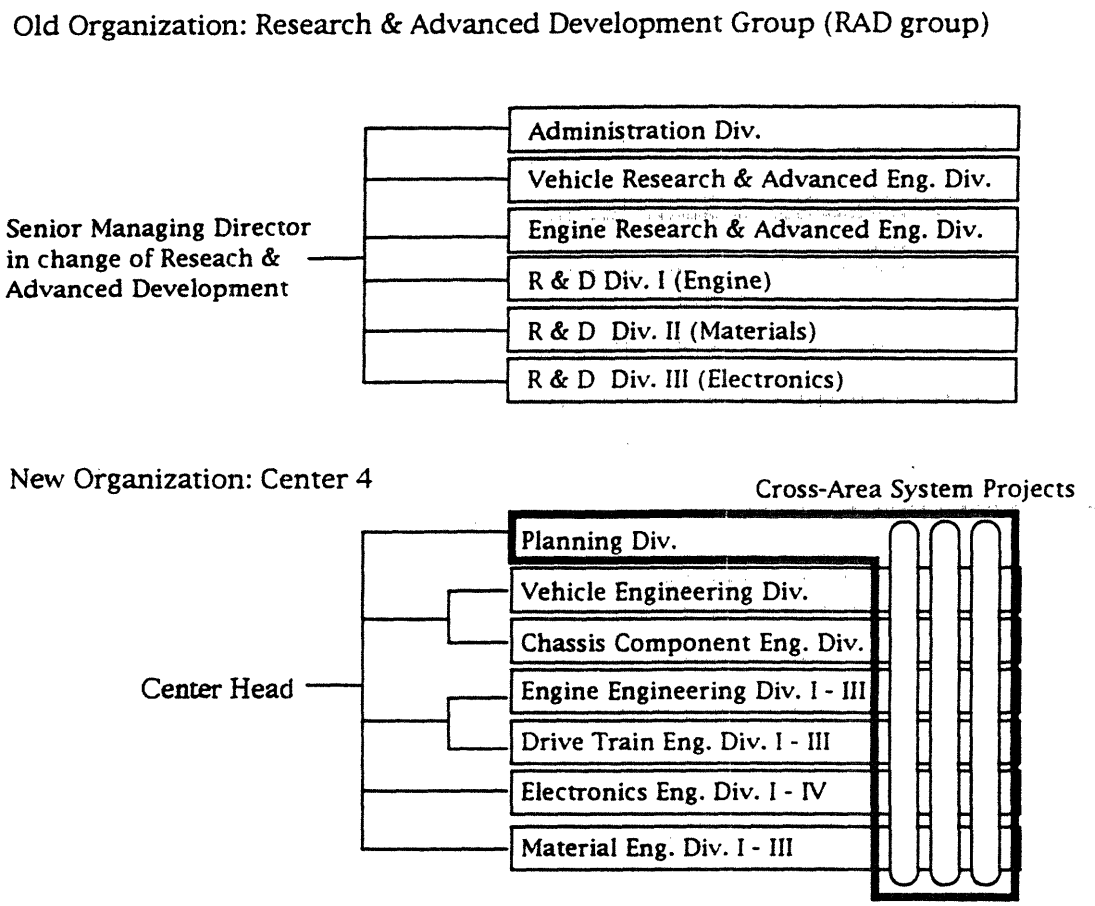
The RAD group had about 2000 people, while there are about 4000 in Center 4. As discussed earlier, some components or systems like electronics and new engines can be developed more appropriately outside specific vehicle projects. Centers 1-3 can now focus on achieving project integrity.

One of the most significant improvements regarding Center 4 was the introduction of a new organizational mechanism, called the cross-area system project. Development of some new systems need new technical knowledge in multiple technical areas. To develop such new systems, Toyota formed a project teams containing engineers and researchers from multiple technical areas. These projects are temporarily located in the Planning Division in Center 4, and their leaders are selected and assigned by the head of Center 4. In the old RAD Group, different technical areas usually worked separately and their coordination mechanism was not strong enough to deal with this type of project.

For example, Toyota recently developed a new low-cost Anti-lock Brake System (ABS). Center 4 was responsible for developing of the new ABS. In this case, similar systems could be used for all vehicle projects. It is not efficient if either an individual vehicle project or a product development center develops this type of new system. Its development needed new technologies in the areas of chassis, electronics, and materials. Toyota thus formed a project team including people from these technical areas to develop the new ABS. A manager at Toyota says that the cross-area system

project significantly improved the efficiency of developing this type of new system component.

Figure 6 Center 4 and its Original Organization



The head of Center 4 is supposed to work on integrating all the divisions of the different technical areas more actively than his predecessor in the old organization. In the old organization, the division managers of the different technical areas were relatively independent. Because in the RAD group, technical inventions within each technical area were important, top management gave each division relatively strong autonomy with respect to research agenda and time frame. The introduction of the cross-area system projects represents the new orientation of Center 4, as well as the important role of its center head.

Toyota Central Research & Development Laboratories, Inc., which has about 1000 researchers, continues to work on basic research as a separate R&D unit. In addition, because Center 4 became less research-oriented, Toyota established a new Research Division internally, and assigned about 500 researchers to this, primarily from the old RAD group.

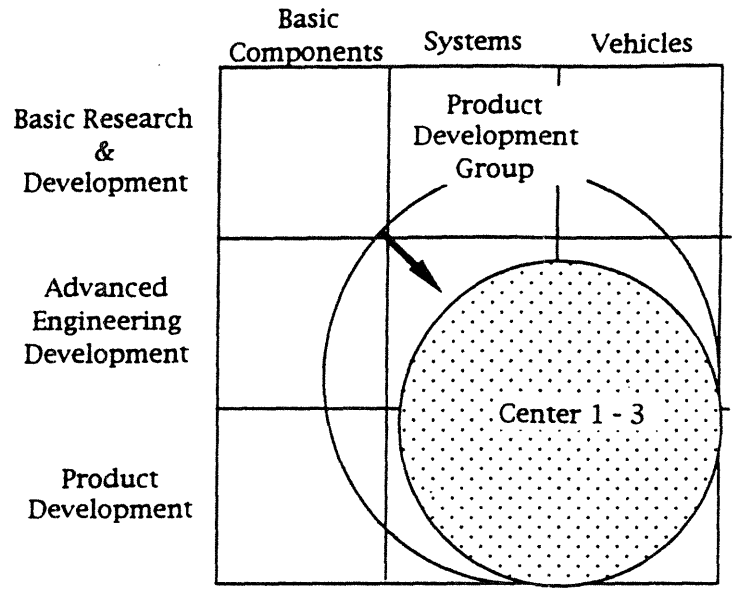
Summary of the Changes in Organizational Structure

Figure 7 summarizes the changes in the vehicle development organization from the old product development group to Centers 1-3, and in the component/system development organization from the RAD group to Center 4. The product development group was simplified in two ways by the new center organization. First, it excluded some areas of component and system development in order to focus on the integration of product development activities, rather than component and system development. This change reduced the number of people in the core product development organization from about 7000 to 5000. Second, the entire organization was divided into three centers. As a result, each center has only about 1500 to 1900 people. It is a drastic change with respect to management scope, if compared with the original size of 7000 people.

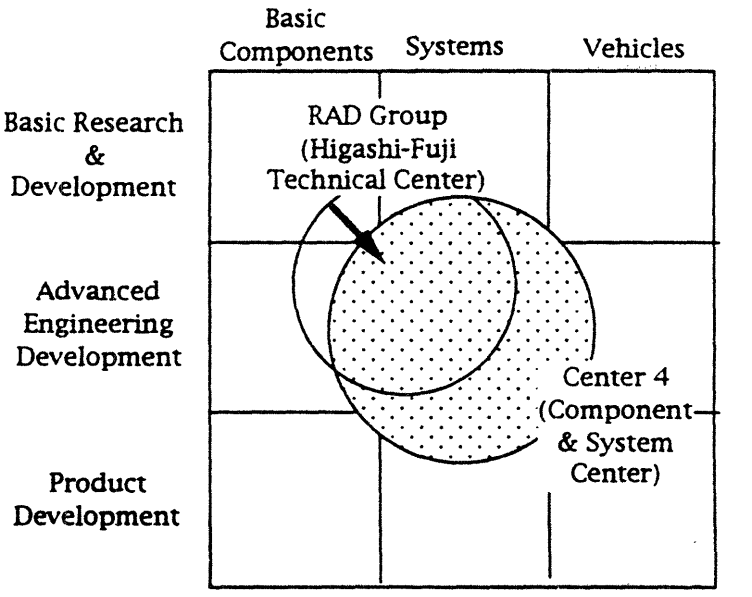
Regarding the component and system development organization, there was a shift in orientation from research to system development. Because Center 4 is responsible for the development of more components and systems than the RAD group, the number of people increased from about 2000 to 4000.

Figure 7 Changes in the Coverage of the Vehicle Development and the Component/System Development Organizations

Change in Coverage of Product Development Organization



Change in Coverage of Component Development Organization



Source: "Outline of Toyota Technical Center", Toyota Motor Corporation, 1991 and 1993

4. Outcomes of the Organizational Changes

Because of the introduction of the center organization, Toyota achieved significant improvements in several areas. In particular, it simultaneously improved both cross-functional project integration and multi-project integration. This section discusses some important outcomes of the reorganization, focusing on these two perspectives, as well as some potential problems of the reorganization.

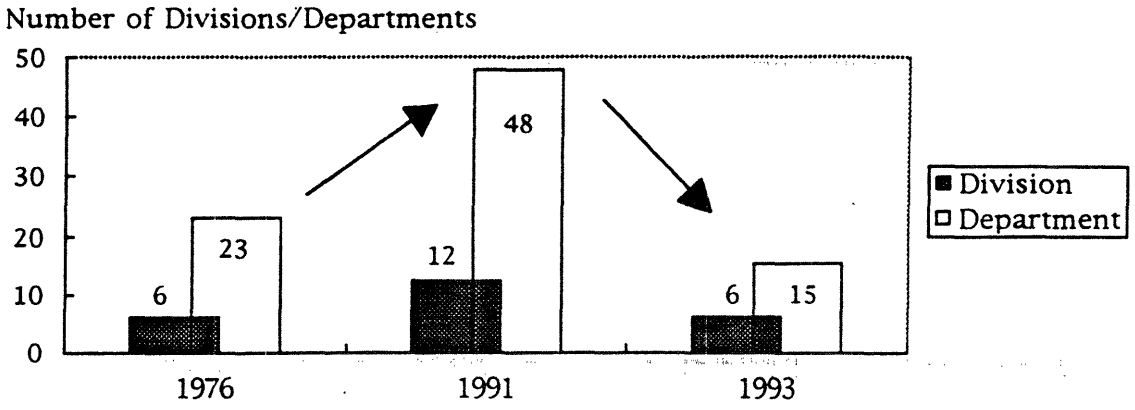
Project Integration through Streamlined Structure

Figure 8 summarizes the outcomes of the reorganization with respect to the reduction of coordination tasks for chief engineers to manage different functional groups. As discussed earlier, before the reorganization, each chief manager had to coordinate, on average, 48 departments in 12 divisions to manage new vehicle development. Primarily because of the reduction in the number of functional divisions and departments, in the new organization a chief engineer has to manage only 15 departments in 6 divisions. Toyota also compared these numbers with those back in 1976, when there were only about 5000 people working for product development. At that time, each chief engineer had to communicate with 23 departments in 6 divisions. The change into the new organization reduced the communication complexity down to the level in 1976, when the Shusa organization worked more effectively than the time just before the reorganization.

Each functional manager and engineer now covers a wider portion of the automobile design. Because of this, cross-functional coordination tasks had naturally decreased among chief engineers as well as engineers, which directly affected the effectiveness and the efficiency of project integration. In addition, it has become relatively easy for functional managers and engineers to see the entire picture of a vehicle project. This change also solved some other problems in the old organization. Engineers can train on the job for the time when they will be promoted to a manager, because they can now obtain knowledge of a broad scope of component engineering.

Engineers can now also obtain more sense of achievement regarding specific vehicle projects. This seems to have positively affected the level of engineers' commitment and job satisfaction.

Figure 8 Changes in the Number of Divisions to be Coordinated



Source: "Activities and Achievements of FP21", Toyota internal document, 1994

Because each functional manager is responsible for fewer vehicle projects than before, it has become easier for a chief engineer to communicate frequently with functional managers. There used to be regular meetings among a chief engineer and the entire functional managers only about once every two months. Now, chief engineers and the six functional managers, as well as the center head, have weekly meetings, called the Center Management Meeting.

The introduction of the center heads also greatly contributed to the improvement of project integrity. Chief engineers both in the old and the new organizations have not assumed formal authority over functional managers. On the other hand, center heads oversee all product development projects, including the work of functional managers. The Center heads can work directly on integrating different engineering functions. Using this position, they also support chief engineers to coordinate different functions. For example, when a chief engineer encounters difficulty in negotiating with a strong functional manager, he can discuss the issue in the Center Management Meeting, and the center head may support the chief engineer. Decisions made as a center can be smoothly and quickly implemented.

In this sense, through the combination with the center head, chief engineers regained the strong authority that the original Shusas used to enjoy.

Table 1 summarizes achievements on some important measurements. The new organization helped reduce development costs on the average project by 30 percent. The number of testing prototypes used in the average product development project decreased by 40 percent. This reduction of prototypes was a primary source for the reduction in development costs. The reduction of the number of testing prototypes has reflected the effective communication in the organization. In order to test many different items in one prototype, an intensive coordination among different design divisions and testing divisions is needed. For example, without appropriate communication, it is difficult to install the testing items for interior equipment and chassis into a single prototype. Because of the simplification of the line of communication and project coordination, Toyota has also increased the extent of simultaneous engineering, which has helped cut project lead time by a few months. Stronger project management supported by the center head may also have contributed to quicker decision making and development processes.

Table 1 Outcomes of the Reorganization to the Center[8]

	Performance change	Major factors
Development cost (average project)	-30%	•Reduction of prototypes •Increase in component sharing
Number of prototypes (average project)	-40%	•Intensive coordination between different engineering and testing functions •Increase in CAE usage
Lead time (average project)	Shortened by a few months	•Reduction of prototypes •More extensive simultaneous engineering

Source: "Activities and Achievements of FP21", Toyota internal document, 1994

[8] We rely on the data a manager at Toyota has provided us. He said that these numbers are based on a comparison of similar projects. We were not provided with details of the measurement methodology. These numbers include not only direct outcomes of the change in the organization structure but also those of accompanying process changes. In addition, some factors that are not directly related to the reorganization, such as the increase in CAE usage, are also included.

Multi-Project Integration within a Center

The new organization strengthened the multi-project management perspective with the strong leadership of the center head and strong support from the center-oriented planning division. Because of the large number of vehicle projects, it was difficult to manage Toyota's entire project portfolio and inter-project coordination. Now, the weekly Center Management Meetings discuss the details of multi-project management. In addition, each center now has its own building so that all members within a center can be co-located. Co-location at Toyota emphasizes the geographical integration of the center members rather than just the members of an individual project, which is becoming common in the U.S.

In order to achieve the integration within a center, to begin with, each center defines its own vision and theme for product development. Sharing a basic vision that focuses on projects within the center helps members effectively coordinate engineering activities. The current development themes of each center are:

- Center 1: Development of luxury and high-quality vehicles
- Center 2: Development of innovative low-cost vehicles
- Center 3: Development of recreational vehicles that create new markets.

One example of the changes can be seen in cost management activities. Targets for development and product costs used to be set and managed mostly at the individual project level, led by individual chief engineers. Most cost management staff members used to work directly for chief engineers and their orientation was the cost performance of individual projects. In the new organization, in addition to the cost management at the project level, each center manages the cost target of all the projects within the center, led by the center head. Cost management staff members are now located in the Planning Division in each center and report to the planning division manager and the center head. Through this new organizational setting, cost management is supposed to add the multi-project management perspective. Specifically, each center has been working on more component-sharing among

multiple vehicle projects, which is one of the most effective ways to reduce product costs. In order to achieve this, project-level management alone was not sufficient.

With respect to component sharing, one critical issue each center is now working on is the reduction of the number of basic platforms utilized among multiple products. For example, in Center 2, currently there are five distinctive platforms: 1. Celica / Carina ED / Caren, 2. Camry / Vista, 3. Corona/ Carina, 4. Corolla / Sprinter, and 5. Tercel / Corsa / Starlet. The planning division manager in Center 2 believes that five different platforms for these compact-size front-wheel-drive models are too many. Center 2 is planning to significantly reduce the number of the platform designs within a few years.

People at Toyota tended to think that, because each of the five platform designs had been produced at the level of more than 200,000 units/year, a distinctive design could be justified by economies of scale. This is true with a distinctive die that is needed for different platform designs, because at that level of production, each die is fully used for its life cycle. However, there are many other areas that could benefit from the reduction of platform designs. Some areas that could expect much cost reduction from platform sharing include prototype production, testing, designing, and component handling. The planning division manager concludes that one of the major challenges for the center in general is to develop multiple products that use as many common components as possible, and still enable each product to provide customers with as much differentiated functions and values as possible. The focus of each Planning Division on the limited number of technically related projects within the firm has facilitated more careful project portfolio management within the center.

With respect to component systems smaller than the platform design, Toyota has started a component sharing program that monitors component and system usage in individual projects. Toyota chose 290 different component systems for this program, which ranges from a system assembly like an instrumental panel to a small component like a door regulator. A center makes a list of a limited number of component variations for each component group. A new product development project

is then supposed to choose a component from the list. When a vehicle project wants to invest in the development of a new component design, it must come up with a new design with a better cost-value ratio than any of the existing components on the list. When a new component design meets the requirement, it replaces one of the components on the list, so that the total number of variations will not increase within the firm. Because of the center organization, management of this program has become practical and effective. In the old organization, because of the large management scope, this type of sharing was not managed properly.

One of the other signs of the integration of center members is a sense of inter-center competition that center heads and members have begun to possess. The three centers have been competing with each other regarding the percentage of cost reduction compared to past projects that had been developed before the reorganization. This competition has a positive impact on organizational learning. The center head encourages engineers to learn any superior processes from other centers[9]. Each center has its own engineering functional divisions such as body engineering and chassis engineering. Three engineering divisions for the same type of technologies and components are competing. For example, when one body engineering division comes up with an effective idea for cost reduction, the other two divisions are strongly encouraged to learn the idea, so that they will not stay behind other centers.

Other activities have started within each center to strengthen the center integration, which directly or indirectly helps multi-project coordination within the center. For example, Center 1 held a design and engineering competition in which groups of young designers and engineers compete with innovative cars for a motor show. Center 3 has started a program called the "Let's Challenge Program," which encourages center members to submit any interesting and useful ideas for new

[9] The competition may have a negative impact on organizational learning in some other firms, if each center tries not to transfer its good processes. At Toyota, this does not seem to be the case.

models. Each center also publishes its own news letter. These activities and programs enhance the intra-center integration,

Potential Problems of the Center Organization

The planning division manager of Center 2 raised two challenging problems. First, it is difficult to balance the chief engineer's autonomy and the center integration. Extensive guidelines given to each chief engineer from the center management may cause a negative impact on the motivation and commitment of chief engineers. Toyota doesn't want chief engineers to think that they should work only on what the center decides. This planning manager believes that the center management provides basic and critical guidelines, in which chief engineers maintain authority. There are six people who play a critical role in the center management: three center heads and three planning division managers. Except for the planning division manager of Center 3, who used to be an engine design manager, five of the six used to be chief engineers. This personnel assignment may help avoid any unnecessary misunderstanding between the center management and chief engineers.

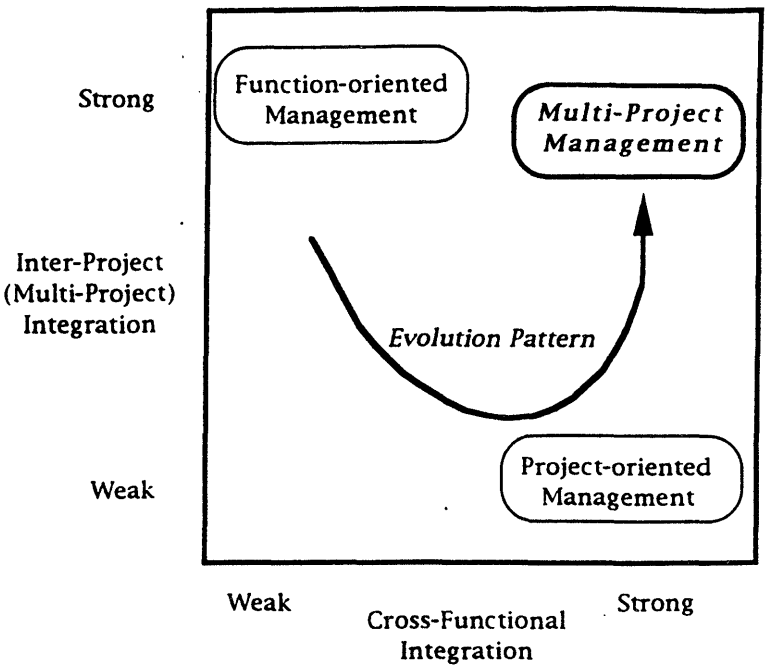
Second, there may be some problems regarding inter-center coordination. The center grouping based on technology and design relatedness aimed at minimizing the inter-center coordination requirements. For example, the old GM organization, which was based on divisions such as Chevrolet and Buick, created difficulties because similar designs and technologies were utilized by products in different divisions and resulted in excessively similar products. Compared to that kind of grouping, the center organization at Toyota is more appropriate for a product development organization that tries to share components and produce distinctive products. However, there are still some problems. The planning manager in Center 2 mentioned one example. When sports-utility vehicles became a hot segment, all three centers proposed the development of such models. Because Toyota doesn't need to develop three sports-utility vehicles in parallel, inter-center coordination was required. Although inter-

center coordination could become the next problem for Toyota, benefits from the inter-project integration within the center seem to surpass the potential problems at this point of time.

5. Discussion and Conclusion

This case study has explained changes in the product development organization at Toyota. There are several important points we can learn from this case. First, this paper confirms that this change was definitely the first major reorganization of product development at Toyota since its establishment of the Shusa organization in the mid-1960s. Figure 9 describes the hypothetical evolution pattern with respect to the organizational orientation in product development. Toyota shifted from a function-oriented to project-oriented structure, and, as Clark and Fujimoto (1991, p. 276-280) discussed, by the late 1970s, most Japanese companies had followed Toyota. By the mid-1980s, some Japanese firms, including Toyota, had shifted to strong project-oriented management systems. This paper has argued that Toyota has shifted again from project-oriented management to multi-project management. One of the most important aspects of effective multi-project management is to improve both cross-functional and inter-project integration at the same time. Cross-functional integration tasks have to be streamlined so that additional tasks for inter-project integration can be done practically. The center organization seems to be a good solution, at least for Toyota.

Figure 9 Evolution Pattern to Multi-Project Management



Second, in order to benefit from the center organization, a structural change of grouping some projects together is not sufficient by itself. Most other automobile firms in the world also employ some type of product grouping. However, the grouping alone does not necessarily lead to effective multi-project management, and organizations at most firms do not seem to work as effectively as Toyota[10]. Toyota made several important changes along with the introduction of the multi-project center organization. For example, it reduced the number of engineering functions in Centers 1-3, and added the component and system development center (Center 4). In this way, each center is simplified enough to simultaneously manage multiple projects within the center. The management scope of center heads and planning division manager is small enough to oversee all activities within the center. A powerful planning division with more than 150 people in each center also seems essential to support the center head. Clear goal-setting specific to each center helps integrate center activities. Each

[10] This statement is based on interviews at Nissan, Mitsubishi, and Mazda. At these firms, one example of the differences from Toyota is that some key functions such as planning and cost management are not divided into centers. However, a comparison with other firms is our next

center is encouraged to compete with other centers in performance, which leads to effective learning within the firm. The center organization at Toyota works effectively because all of these supporting mechanisms have been carefully designed.

Toyota seems to have established an organizational structure and process for product development that will set new standards for international bench-marking. This change has also come at an appropriate time. Because many other competitors have adopted heavyweight product manager system, in which Toyota had enjoyed leadership in the 1980's, Toyota's advantage over competitors had been disappearing. However, we may not exactly know the real benefits or problems of the new organization because new vehicle projects that started after the reorganization have not been introduced to the market yet. We need to continue to study the center organization at Toyota, as well as similar organizational changes in other automobile firms.

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research agenda, and we need to wait awhile before reaching a conclusion.

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