Thinking Beyond Lean

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This book is about how to get the most out of product development. How can firms create new products that share key components but ensure each product will differ enough to appeal to different customer segments? Multi-project thinking, maximizes the chances that the organization will produce a stream of new products that cover a range of market segments. Projects that share components and engineering teams can deliver many products quickly and utilize new technologies. To make this possible, special organizational mechanisms and processes are necessary.

Introduction

A critical decision for automobile companies, or for that matter, any company building a complex product with many components or subsystems, is whether to use a functional or a project structure. This involves several issues, such as:

- Which functions should companies keep centralized to take advantage of scale and scope economies by providing engineering services and components to more than one project?
- Which functions should companies disperse among projects in order to maximize the distinctiveness and innovativeness of the individual products?
- How much authority over budgets and personnel should a project manager have compared to managers of functional departments?
- To what extent should companies seek a balance of functional and project management by grouping related projects together and then sharing some technologies as well as functions at least for clusters of similar projects?

This fascinating book by Cusumano and Nobeoka explains the principles of lean product development. Lean thinking, which emphasizes less of everything - fewer people, less time, lower costs - can significantly improve project performance. During the 1980s, for example, many Japanese automakers used heavyweight project managers, overlapping phases, and other techniques when they replaced and expanded their product lines nearly twice as often as U.S. and European companies.

But to get the most out of their investments, leading companies have already shifted their attention beyond simply the efficient management of individual projects, which may enjoy so much autonomy that they result in “fat” designs – too few common components and too many unnecessary features and options. Then the company may fall into the trap of optimizing product development for the good of each project rather than for the good of the firm as a whole.

The best way to work for the good of the firm and create a portfolio of products at low cost is to shift into a multi-project mode. A firm must develop some totally new products but pay equal attention to developing common core components and quickly sharing these across multiple projects. Multi-project management, requires conscious, planned efforts to link projects, through product portfolio planning, design of common core components, and overlapping the responsibilities and work of project managers and individual engineers.

Knowledge sharing is the essence of multi-project management. Knowledge can be shared across projects in various ways:

- Projects may develop platforms primarily from scratch. This is most appropriate for incorporating the latest technology or totally new designs without placing many restrictions on the development team.

- In concurrent technology transfer, a new project may borrow a platform from a base or preceding project after the base project has completed its design work. Generally, this transfer occurs within two years of the introduction of the original or base platform.

- In sequential technology transfer, a project inherits a platform from a base project that has finished its design work. The second project reuses a platform that already exists. The reused platform is already old compared to designs transferred while a base model is being developed, as in concurrent technology transfer. Design constraints may be very high in sequential technology transfer because engineers from the two projects cannot make adjustments in the platform to suit the different products.

- In design modification, a project replaces an existing product but without creating a new platform or borrowing a platform from another product line. The modification project simply inherits or reuses the platform from the predecessor model in the same product line, perhaps with some minor changes.

Different companies, different experiences

In the 1980s, Chrysler developed a new platform only once. Over the next decade, it utilized this same platform with some modifications in a series of new models. This reuse strategy was extremely economical. But by the early 1990s, Chrysler faced another crisis due to negative customer reactions to its old and tired looking products. It then faced the challenge of creating new platforms for most of its existing models within a very short period of time.

The French company, Renault would often develop new platforms each time it replaced a product or added a new product line. It was an expensive strategy, however, due to the costs of developing so many new platforms. This approach also limited the number of new products and replacements the company introduced.

Honda followed a different strategy in the late 1980s. It developed a new platform for one product line and then, in parallel projects, quickly transferred this platform to other product lines.

But the one company from which a lot can be learnt is Toyota. The authors cover the product development practices of this company in great detail.

The Toyota Experience

Toyota has been a leader in adopting new organizational structures and processes in both manufacturing and product development. For firms in many different industries, it has served as a benchmark for performance in these areas. It is interesting to examine how Toyota has streamlined its product development activities over time.

In 1953, Toyota assigned the first shusa, or heavyweight project manager, to a new vehicle project. Toyota strengthened the organization in 1965 by formally establishing a product division to organize and support shusas. There were already 10 shusas in the company. Each shusa had 5 or 6 staff members. Toyota did not change the product planning division and shusa system until 1992, when it introduced the center organization.

In the early 1990s, Toyota decided to reevaluate its entire product and technology development organization, even though at that time, there was no compelling need to do so. Toyota was actually doing better than most of its competitors. Toyota identified two important problems. It had become less efficient in internal communications. Coordination tasks needed to manage new product development had become complicated. Second, the competitive advantages of Japanese auto makers decreased significantly after around 1990, due to the rising yen and efforts by foreign competitors to close the gap in product development as well as manufacturing.

Toyota's product development organization was a huge matrix that gave roughly similar weights to functional areas and projects. In theory, chief engineers at Toyota had authority over the entire product development process, from concept generation through design and manufacturing. In practice, they found it difficult to control and integrate different functional divisions when developing a new product. In 1991, a chief engineer had to coordinate people in 48 departments in 12 divisions to launch a new product effort. Toyota had to address various issues:

- There were too many functional engineering divisions and too narrow a specialization of engineers.
- There were too many vehicle projects for each functional manager.
- It had become much more complicated and difficult for chief engineers to oversee all the engineering functions.
- Coordination across projects was lacking.
- Management did not sufficiently coordinate the work of the advanced components technology group (RAD) and individual vehicle projects.

Toyota executives realised that they needed to position new products more carefully within their portfolio to reduce cannibalization. At the same time, to reduce production costs, it was necessary to increase the level of sharing or commonality of components.

In 1992, Toyota divided its new product development projects into three development centers. Center 1 became 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. Toyota had considered other grouping schemes, such as by product segment (luxury versus economy versus sporty cards, or small versus medium versus large cars). Toyota management did the grouping based on platform similarity because it believed this would lead to the highest level of technology sharing among projects within a center. Managers concluded that using common platform designs for multiple product lines would reduce engineering investments and production costs most effectively.

In 1993, Toyota created Center 4 to develop components and systems for all vehicles projects. It reorganized the Research and Advanced Development Group (RAD Group) and assigned most people from this group to Center 4. While the RAD Group worked on research and advanced development independently, Center 4 supported vehicle development by providing specific projects with components and subsystems.

Toyota reduced the number of functional divisions for design engineering. It also lessened the specialization in each functional engineering division. In the new organization, the interior engineering division merged with the body engineering division. Each design engineering division now had wider design responsibilities. This did not enlarge the size of the functional divisions because each of them was now responsible for only a limited number of projects within the center.

Toyota reduced the number of functional divisions involved in a specific project through Center 4, the component and system development center. By developing some components and subsystems outside specific vehicle projects, Centre 4 simplified the work of the first three centers.

Toyota considered various factors when determining whether particular engineering functions should be in a vehicle project or in Center 4. Components that needed extensive tailoring for each product were kept within the particular project as were components that needed careful coordination with other parts of the product design. Components with modular characteristics were kept separate from specific vehicle projects and then inserted into a product design relatively easily. So they were given to Center 4. And Center 4 was also used for components that required a lot of new technical knowledge. Such development efforts usually required a group of technical specialists working together. Such components also sometimes needed a long time to develop and did not fit the time frame of regular vehicle projects. Sometimes, components varied significantly from project to project. For example, the upper-body design directly visible to the customer was different for each product. Engineers had to carefully coordinate its design with other parts of the product, such as the chassis and interior. Therefore, Toyota decided to manage the upper-body design within a project and to maintain this engineering function with each of the three vehicles centers. On the other hand, components like batteries, audio systems and air conditioners did not usually need tailoring for each different vehicle project. Therefore, Toyota moved the engineering divisions that developed these components to Center 4.

One of the most significant improvements regarding Center 4 was the introduction of a new organizational mechanism called the "cross-area system project." Developing some subsystems required new technical knowledge in multiple areas. To create such new components, Toyota decided to form project teams containing engineers and researchers from multiple technical areas. Toyota temporarily located these projects in Center 4 and the head of Center 4 selected and assigned their leaders. In the old RAD Group, different technical areas usually worked separately, and there was not enough coordination to deal easily with this type of project.

The new center organization simplified product development in two ways. First, it excluded some areas of component development in order to allow projects to focus on the integration of activities, rather than component development. Each product development center also became manageable with only about 1,500 to 1,900 people compared with the 7,000 people in the earlier product development organization.

In order to achieve better integration within a center, each center also now defined its own vision and theme for product development. Sharing a basic vision that focused projects within the center helped members effectively coordinate engineering activities. In the mid 1990s, the development theme or focus of each center was as follows:

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

The three centers began to compete with each other to reduce costs, using products developed before the reorganization as benchmarks. Unhealthy competition might have had a negative impact on organizational learning if each center tried to hide its good processes and technical advancements. At Toyota, however, this did not seem to be occurring. Senior executives and the center heads strongly encouraged engineers to learn as much as they could from the other centers and to share innovations with the other centers.

Trends in Product Development in the Global Auto Industry

In the mid-1990s, four types of product-development organizations were commonly used in the auto industry.

- Matrix organizations combined projects with permanent functional engineering departments. There was usually a project manager or project coordinator who often belonged to a centralized product-planning department. Companies then imposed some form of project organization over relatively strong functional engineering departments. The projects drew members from the functional departments. Engineers usually reported both to the project managers and the managers of their functional departments.

- In project team organizations, companies focused on building one product at a time, through they might build multiple variations of the product (such as different body styles) in the same project. There were minimal barriers between the different functional departments because all engineers belonged to the project team and usually co-existed physically. However, firms with several projects duplicated many functional activities or component development efforts.

- The third and fourth types were the semi-center and center organizations. Here, companies created clusters of similar projects and duplicated some functional departments for these groups of related projects. There were only two cases of "pure" center organizations that duplicated most functional departments for the different clusters of projects – Toyota and Ford. Others used semi-center organizations. They had centralized functional departments that provided most of the components or engineering services to all projects. They mixed these centralized departments, however, with clusters of projects (semi-centers). The clusters included a matrix structure that broke up some key functional departments (for example, body design) just for the projects grouped together.

Renault

Renault used a conventional matrix, with permanent functional departments (design, quality, product and process engineering, power trains, purchasing, and manufacturing) as well as projects that drew personnel from the engineering departments. In the 1990s, the French car maker struggled to improve development lead times, costs, and quality. Renault tried to capture market share by producing a hit product, rather than trying to compete with a full line of products that covered every market niche. This meant that project teams were much more interested in creating distinctive products than trying to share platforms or other components. But producing hit products in a fast-moving trend-oriented industry was not so predictable and was a risky strategy.

Mitsubishi

Mitsubishi had seven passenger-car groups: luxury cars, sporty cars, mid-size cars, economy cars, recreational vehicles (RVs), light vehicles, and commercial vehicles. A project manager supervised each of the groups and managed several related projects. Project managers also supervised individual project engineers, who headed each project. Both project managers and project engineers belonged to a centralized product development office that coordinated project engineering and project plans. Each project drew personnel from the permanent functional departments, such as for body design, chassis design, various components, and testing. As in a traditional matrix, engineers working on new products reported both to managers of projects and to managers of their home functional departments. The company adopted a formal system for creating common platforms rather early among Japanese auto makers. It put more direct emphasis on platform sharing and used its planning process to direct product development activities rather closely. Even products that had very different characteristics began to share common platforms from the early 1980s. Mitsubishi managers also realized the importance of simultaneously developing multiple products that shared a common platform.

Fiat

Fiat used a matrix organization, although it had made some important modifications to this structure. Since 1990, Fiat had utilized platform teams that built families of similar products from the three brands using the same platform. It also gave platform directors (multi-project managers) as well as project managers more authority than in a traditional matrix. As a result, Fiat had elements of a semi-center structure and a product team organization. Because it had different brands and many models with distinctive images but similar size and performance characteristics, portfolio planning was a particularly important exercise for Fiat.

Chrysler

In February 1989, Chrysler abandoned its traditional matrix organization in favour of product teams. In its old matrix system, Chrysler had powerful functional engineering departments as well as weak project managers who served as little more than project coordinators. Typical of other companies using a matrix system, including Toyota, Chrysler's project coordinators had great difficulty overseeing the work of so many functional departments. With the introduction of platform teams, Chrysler abandoned its strategy of sequential technology transfer, which it had relied on throughout the 1980s. Management charged the platform teams with quickly building new designs as well as producing multiple models based on these platforms. Each platform team became essentially one large project (or product) team working on multiple body styles.

Honda

Honda had developed a reputation for innovative product designs and advanced engine technology. This reputation required an effective mix of project management skills and functional skills in engine R&D. Honda assigned most engineers full time to specific product teams. When it started work on a new product, Honda formed a temporary project team that resembled a task force of engineers from different functional areas. The team members dispersed after they delivered the final product. Honda did not co-locate all the engineers on one project. Honda was by far the most active company in introducing new engines during the 1980s. Each engine involved an investment of at least a billion-dollars. Project managers made these investments simply because they did not want to reuse engines from existing products. By the early 1990s, Honda management had recognized the need to coordinate its engineering groups and projects better in order to promote more technology sharing and cost reduction. From the early 1990s, project managers were given less freedom to build new engines. Unless they had top management approval and special budgets, engineers had to create new engine designs that reused existing manufacturing equipment. During 1991-1992, Honda made considerable progress in standardizing not only the platform but also approximately 50 percent of the components across three product lines – the Civic, Integra, and Domani.

Mazda

In August 1993, Mazda abandoned its traditional matrix organization in favour of product development centers. Like Toyota, it established three centers. But declining sales and increased integration with Ford pushed Mazda into a matrix system. Top executives decided that the matrix structure would help them keep engineering departments centralized and small, with no redundant groups. Related to this decision was pressure from Ford to use more common platforms and components. Mazda reverted to a matrix structure in stages. In July 1995, it reduced the number of development centers to two, one for sedans and sports cars, and another for recreational vehicles. Then, in September 1996, Mazda went back to a pure matrix organization. Managers and engineers welcomed this change because, in practice, the semi-center structure had never worked very well. Because Mazda was unable to increase the number of its product lines, managers found it difficult to separate technically related products into three separate groups. There was always plenty of overlap in components. Given this technical overlapping as well as a shortage of money and people, it did not make economic sense to try to divide limited engineering resources into three groups. Since a Ford manager became president of Mazda in 1996, sharing platforms between Ford and Mazda became more important as an objective than sharing components across Mazda projects. The matrix system made it easier not only to manage projects centrally but also coordinate development work with Ford.

Nissan

Compared to Toyota and other Japanese auto makers, Nissan's engineering organization had been more functionally oriented for many years. Nissan executives generally emphasized innovation in specific areas such as engine technology or body design styling as their primary method for competing against Toyota. They gave primary authority over budgets and people to managers of the functional engineering divisions. Nissan's three centers grouped vehicles by platform commonality: front-wheel drive (Center 1), rear-wheel drive (Center 2), and recreational and commercial vehicles (Center 3). In 1996, however, Nissan limited the scope of the engineering work done in each center, as opposed to centralized functional departments. In mid-1997, the company announced a new initiative to reduce the number of platforms. It decided to utilize just one platform for new mini-car, station wagon, and sport-utility models being produced in Europe.

General Motors

Despite having too many products that looked very similar, GM's 1993 models used more than 200 different steering columns, 89 steering gears, and 44 power-steering pumps. In 1992, GM started to bring together its various design, marketing, components, and manufacturing groups. In particular, management imposed centralized control over all design, engineering, and technical staff by combining these under the umbrella of a Vehicle Development and Technical Operations (VDTO) Group, also known as the GM Technical Center organization. In October 1994, GM merged its four separate passenger car development groups in North America into two groups – one for small cars (including the formerly separate Saturn division) and one for mid-size and luxury cars. It retained a third group for truck platforms. These groups did design and some component engineering work for multiple products that GM sold under different brand names. GM centralized product and process engineering to a great extent. The four development groups in North America and Europe were like Semi-centers, similar to Nissan, and not full development centers, as in the case of Toyota or Ford. The Vehicle Launch Center (VLC) acted as an incubator for new products, allowing projects to share process knowledge as well as components more easily. Engineers working on a new product came to this center for the first two years of a project. GM co-located product teams on one floor in the same building to foster face-to-face communication. The VLC also had a permanent staff of approximately 40 new product development experts. They worked on development process standardization, cost reduction, and components sharing across projects, as well as group dynamics, problem solving, and quality management. After two years, the product team members returned to their functional departments to complete development work, although the VLC staff remained. Their accumulation of experience, as well as documentation and other information they collected, helped GM replicate the product launching process with different groups.

Ford

Similar to Toyota, each center at Ford included most engineering functions, except for concept design. Ford created this structure between 1993 and 1995. In 1993, management announced a restructuring program called Ford 2000 and started reconfiguring its product development organization. In January 1995, Ford divided its product development organization into five vehicle centers, one each for small/medium, large front-wheel-drive (FWD), rear-wheel-drive (RWD), light-truck, and commercial-truck vehicles. One of the vehicle centers, which developed small and medium size vehicles was spread over two locations in Europe (England and Germany). Ford located the other four vehicle centers in Michigan (USA).

The authors have found considerable evidence of lean thinking in the way auto makers in the 1990s have been managing individual development projects. Most firms have been speeding up projects by overlapping phases and giving more authority to project managers and product teams. More auto makers are trying to manage across projects by sharing platforms and other components. Among firms that have moved beyond simple matrices or product teams to coordinate multiple projects, the most popular organizational innovation seems to be multi-project managers. Even firms that have a tradition of strong functional departments and only weak project managers, such as Renault and Fiat, have changed their matrix systems. They have adopted more powerful project managers, product team or platform team concepts, and engineering teams that develop components for multiple projects as part of a differentiated matrix.

Strategies for Product Development

To develop truly innovative products, a firm must change its existing organizational processes or at least create a separate organization. In contrast, to create incremental innovations, which is the norm than the exception in car making, a firm often needs to make key organizational processes routine in order to maximize effectiveness. Sharing of expertise across projects becomes important

The impact of the new product introduction rate on market performance is important when two general conditions hold. First, the technology improves steadily in small increments, instead of through radical improvements only once in a while. This makes marginal superiority the basis for product competition in the marketplace. Second, customer expectations appear fragmented and change at a rapid pace, predicted by current fashion trends and social values. Therefore, “freshness’ in styling, in addition to product functionality, has a significant influence on sales. The automobile industry probably meets both these conditions.

Firms can leverage key technologies from existing products in two different ways. They can use existing technologies in a product redesign or replacement project. In other cases, firms can transfer the technologies to another product line that targets a totally different market segment. In the first case, firms try to enhance the competitiveness of their original product. In the second case, they try to extend their investment to move into a new market segment and achieve economies of scope in development. Both applications involve incremental changes, but they have vastly different implications at the corporate level.

With regard to timing, the speed with which a firm can exploit existing technologies is a critical factor affecting its competitiveness. The technology that a firm modifies and exploits may be nearly obsolete or still relatively new. It is reasonable to assume that even competitive technologies eventually become outdated as time passes. Therefore, if a firm utilizes the same technologies in different products, how fast it can accomplish this transfer should affect how products fare in the marketplace.

Multi-Product Strategies and Project Performance

Only through concurrent technology transfer can a company reuse technology from a base project in another project and effectively share tasks among projects as well as make mutual adjustments and conduct joint design work. Projects can most effectively and efficiently implement mutual adjustments when there exist overlapping and intensive communication among the functional groups.

Transferring and reusing an old design may not be efficient if engineers apply the old design or reuse old components in ways that do not properly meet new customer needs or match competitors’ products. When a new project transfers a platform from a preceding project, the new project usually needs to adjust the base platform design to fit the new product’s individual architecture or specifications. Many factors may prompt changes in the platform design. These include different target markets, different performance requirements, and changes in customer tastes. In addition, linking technologies between the platform and other components, such as the exterior body, engine, and suspension system, often differ between a base product and the new product. Body designs usually differ between two products.

Even with an advance plan during the base project describing how a future project would reuse the platform design, there may often be unexpected adjustments required during the new project. It is almost impossible to make accurate plans to modify the base platform for reuse in the new project when there is a long time lag between two projects. It is difficult for engineers in the base project to predict problems a future project may have in reusing the old platform design. In particular, many problems in the linking technologies surface only after the new project starts and engineers design other components and begin testing prototypes. In many cases, platform engineers cannot complete the necessary adjustments or changes in linking technologies without consulting the component engineers.

Adjustment processes are often so complicated that engineers can do these more efficiently only through exchange of ideas between two projects. Only concurrent technology transfer projects have significant overlap with a base project. Only in concurrent technology transfer can engineers designing components make mutual adjustments with the base projects. In addition to mutual adjustments, because of the overlapping and interactions, two linked projects also can share engineering tasks and project resources.

In sequential technology transfers or design modification projects, companies usually transfer the design from base projects through drawings and written specifications. Engineers may have completed the base projects already and started working on other products. Some engineers may have even left the firm. Therefore, engineers on the new project can have a hard time finding and communicating with engineers who worked on the old base platform. These issues are important because face-to-face technology transfer can be much more efficient than transfer through specifications and drawings in case of complex knowledge transfers, such as for vehicle layouts or subsystem integration.

Companies which use technology transfer extensively usually have general managers or vice-presidents responsible for product development above the project managers. These higher level general managers supervise multiple products and projects. These executives also are likely to oversee both a base project and a concurrent technology transfer project because the time lag between these projects is short. With a long time lag, it is likely that the same general manager is responsible for both a base project and a sequential technology transfer project, or for both a base project and a design modification project.

Multiple functions, at least to some extent, often require sequential tasks. For example, manufacturing preparations for a new product cannot begin until engineers have completed a significant amount of work on the details of a product's design. As a result, an attempt to overlap functions too much, such as in aggressive concurrent or simultaneous engineering approaches, could lead to wasted effort and other problems. In particular, component engineering groups or manufacturing engineering may have to do considerable rework if design engineers continue to make changes in the product specifications late in a project. Engineers can avoid some of this rework through frequent exchanges of information and continual integration of design changes.

Simply overlapping projects, does not automatically provide a firm with all the efficiency benefits of concurrent transfers. Overlapping projects that share components creates significant interdependencies between these projects. It makes it difficult to coordinate across projects as well as across interdependent functions, like body or component design and process engineering. Companies need to figure out which components to share. Then they need to introduce specific organizational structures and processes that facilitate coordination across projects and functions as well as the process of mutual adjustments, task sharing, and joint design.

Lessons for Managers

Project-centered organizations have certain advantages. They help break down walls between functional departments. On the other hand, in functional organizations, engineers are more likely to be aware of the latest technologies. They accumulate technical expertise by specializing more and staying together, rather than forming and disbanding project groups every time they complete a product. Functional departments may thus be in a better position to produce radical innovations in particular technologies.

A matrix that combines projects with functional departments may obtain some of the advantages of both approaches, but it also creates peculiar problems. One relates to the level of authority held by the project manager as opposed to the functional department managers. This issue can become cumbersome when difficulties arise that cut across areas and there is disagreement on how to solve the problem. Should functional department managers have the final say based on their technical expertise? Should the project manager have the final say based on his or her responsibility for the whole product? Or should more senior managers resolve disagreements between functional managers and the project managers?

The second common debate relates to the responsibilities and physical location of engineers. Should an engineer remain with a functional group in order to be among other engineers working on the same component for other products? Or should management view engineers as members of a project team and co-locate them with other engineers working on the same product? The issue, again, is strategic, not simply organizational: Do managers want to optimize a particular technology or component, and maximize the chances of innovation in specific domains? Or do they want to optimize integration of components and balance the cost, quality, and performance of the whole product?

Three conditions determine whether a project-centered or a functional organization is more appropriate:

- the rate of technological change,
- the length of the development project,
- the degree of interdependency among the functional components being developed for the product.

In the case of rapid technological change, engineers located within a product may become detached from information on the latest advances in their field. Also, if the project takes a long time, engineers located in the project may lose touch with the state of the art expertise in their fields. And if there are few interdependencies among the functional components in a product, then there is little need for a project-centered organization.

Functional managers generally have considerable authority that cuts across various products. If lowering costs is a major objective, then functional departments are useful since they have the ability to standardize components across multiple products. Functional departments are better than project organizations at transferring technology as well as reducing task duplication in different product development efforts.

Simply promoting technical excellence through a functional organization is inadequate in today's competitive markets. Customers around the world now expect high-quality, reasonably priced products. This demands a skilful integration of different components or subsystems as well as different functions, such as design and manufacturing. For complex products, it is not possible to create individual components and sub-systems independently. Companies have to integrate functional departments in some way. Project-centered organizations have the ability to create differentiated products with an integrated or cross-functional management style. Companies should combine this ability with a direct mechanism to share technologies and knowledge across multiple product lines and projects.

A differentiated matrix provides a balance that minimizes the conventional trade-offs between a functional and a project oriented structure. It allows functional groups to focus on components that need to be standardized across multiple projects. But it also allows projects to create distinctive products by creating separate groups for those components that truly differentiate products, such as exterior parts that are directly visible to the customers. To make the differentiated matrix structure work, however, a company needs to have a strategy for creating sub-systems or common components and then for sharing these across products. It also needs to organize and coordinate these different groups and project teams.

In case of components, documents, reports, written engineering standards, and computerized tools, can be more effective in promoting knowledge retention than transfer of people or direct communication between members of different projects. This seems to be because component-level knowledge is rather specialized and possible to write down.

For system or integrative knowledge, companies will do better if they rely more on face-to-face communication and transfer of people from one project to another. Integrative knowledge is difficult to communicate and write down. For example, car engineers try to integrate components such as the engine and transmission with the body shell and platform in a way that minimizes vibrations and noise. The integration requires knowledge of many different areas, both in design and manufacturing. Engineers need to learn how to do this kind of design work through experience. What they need to do may vary widely from project to project. So, it is difficult to write down or codify this type of knowledge.

It is important to improve integration across different engineering functions as well as across different projects simultaneously. Toyota provides an excellent example of how to do this. Its center organization facilitates coordination among technically related projects.

At the same time, Toyota has improved integration across functions by strengthening the authority of project managers vis-à-vis functional managers. Toyota has also streamlined tasks for integrating across functional groups in order to make it easier to integrate multiple projects.

There must be a logic for grouping projects. Then supporting mechanisms and processes for multi-project management must be put in place. Firms need to decide whether this grouping should be by market similarities or technical similarities in the products themselves. In the automobile industry, creating groups of projects around common platforms seems far more effective for promoting technology sharing than other schemes. But creating centers for technically related projects still does not necessarily lead to effective multi-project management. Many companies have adopted platform groups or development centers or semi-centers. But they do not seem to work as effectively as Toyota.

Toyota seems to work so well because of better execution. For example, Toyota executives have brought technically similar projects together but they have also maintained a consistent design philosophy for their products and reduced the number of engineering functions in the three vehicle development centers. In addition, Toyota has added a fourth center for common component and subsystem development. Now, the management scope of the center heads and planning division managers is small enough to allow them to oversee effectively all activities within a center. In addition, Toyota has added a powerful planning division of more than 150 people to each center to support the work of the center head. Furthermore, Toyota has created specific development goals or themes for each center, which appear to help managers and engineers focus their efforts. Finally, Toyota executives have encouraged the centers to compete on performance and then share what they learn. This sharing promotes company-wide improvement, efficiency, and innovation.

How strategically a company creates new products and replaces old ones has become important today. The efficient management of one project at a time is no longer adequate for companies to succeed in highly competitive global markets. As pressure increases on companies to launch more products at lower costs, the concept of multi project management will become even more important. That calls for strategic thinking backed by efficient ground level implementation.