Managing Rapid Technological Development

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The introduction of new technology into products is accelerating in industry after industry. Today, the pace at which companies introduce new technology has become a principal determinant of competitive success – or failure. Arthur D. Little has had extensive experience assisting organizations worldwide with this very issue. In these pages, we offer specific approaches that can help to ensure the rapid introduction – and effective management – of technological change.

Forces Driving Rapid Technological Development

Two factors are driving the trend toward rapid technological development: the money to be made by being fast and first, and the recognition by many companies that rapid technological development represents a form of know-how that can yield tremendous competitive advantage.

The Money to Be Made. In a study undertaken by Arthur D. Little for an automotive company, we constructed a simple financial model of product development. The base program, in this instance, had a lead time for product development of five years and a computed net present value of about $2 billion. The model allowed us to conduct a number of sensitivity analyses of the net present value.

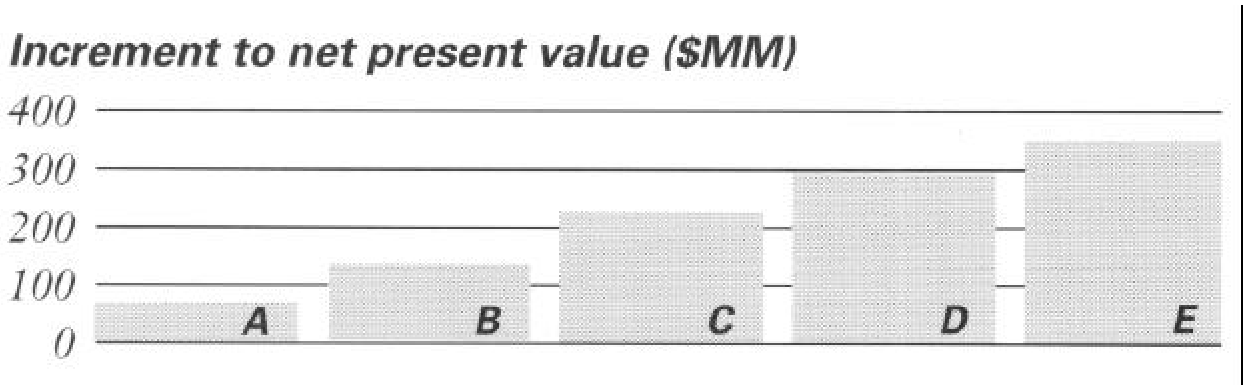
If we cut R&D expenses by 2 5 percent and are able to ensure no adverse impact on product quality or on lead time – a difficult task – net present value goes up by roughly $70 million, as Exhibit 1 shows. If we cut investment costs – that is, facilities and tooling – by 20 percent, while providing the same assurance, net present value goes up $145 million.

If through effective product development we can cut product costs by just 2 percent, net present value jumps by $2 3 5 million. And if perceived product value can be enhanced enough to produce an incremental volume increase of 10 percent (e.g., in Exhibit 1, market share goes from 20 percent to 22 percent), then net present value jumps by almost $300 million.

What is most fascinating, however, is the effect of reducing lead time by 20 percent, or one year: Net present value increases by almost $350 million. For this product, the manufacturer would put almost $7 million in the bank for each week saved in product development lead time.

Exhibit 1

The Rewards of Better Product Creation



Base program

A *Reduce R&D expenditures by 25 percent without affecting product cost, quality, or timing.*
B *Reduce investment in facilities and tooling by 20 percent with no impact on production.*
C *Design product for 2 percent lower production cost without reducing product appeal.*
D *Increase product appeal so that sales volume increases 10 percent without increasing cost.*
E *Reduce development lead time by one year with no impact on product cost or quality.*

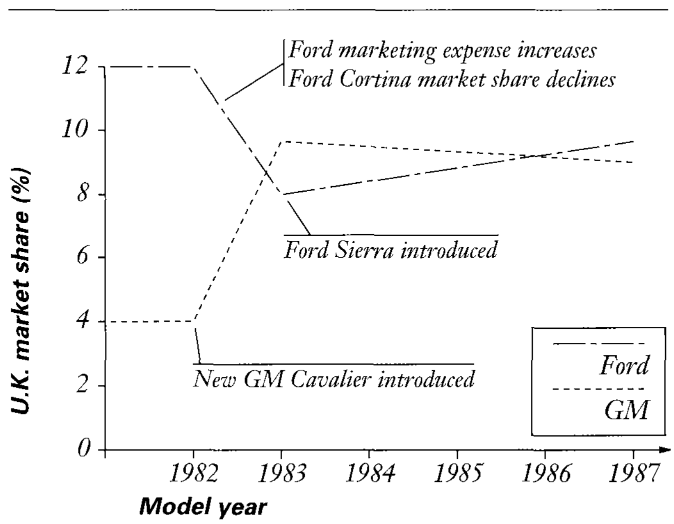
Assumptions
New car; five-year development period; $1.5 billion total investment; five-year life; base program NPVof$1.95 billion

Another example also comes from the automotive industry. In the early 1980s, Ford Motor Company commanded a significant lead in the compact car segment of the United Kingdom market (Exhibit 2). When General Motors managed to scoop Ford by a year in the introduction of a new model, Ford lost not only significant market share but market leadership. In its effort to regain leadership, Ford had to pump a lot of value into a competing model at no added cost to the customer. Although Ford eventually regained the lead, the cost of the one-year time disadvantage was approximately $1 billion of lost profit over five years.

Speed as a Competitive Weapon. The second factor driving rapid technological development is its use as a competitive weapon. Exhibit 3 shows the lives of portable hi-fi models over the last decade. On average, model lives have declined from two years to one year. The pressure to introduce new models frequently has been less at the top end of the model line – that is, Sony – than at the bottom, presumably because consumers are less willing to replace more expensive equipment. But in achieving rapid introduction of new models, other manufacturers – particularly Panasonic – may have learned a trick that will some day come back to haunt Sony.

Exhibit 2

Strategic Value of Time to Market



Achieving Rapid Technological Development

Our research suggests that an organization's ability to achieve rapid technological development is influenced by three variables: the rate of change of product designs, the number of models in existence, and the complexity of the product.

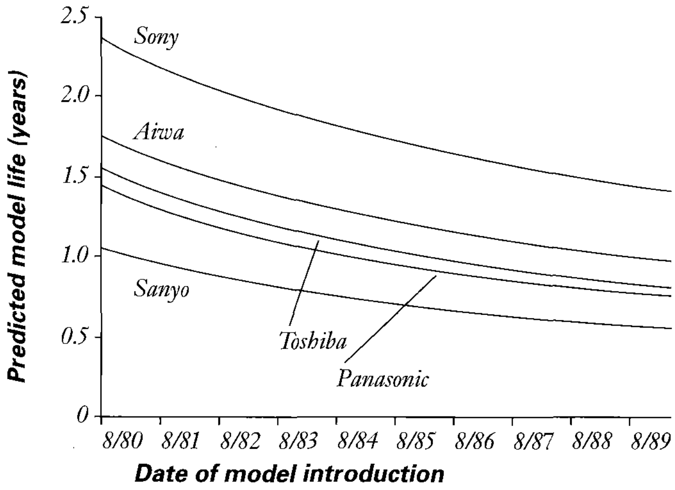
The first two of these dimensions are charted in Exhibit 4. Products in the regions labeled „dynamic“ and „turbulent“ are current competitive battlegrounds. The more complex products tend to fall into the dynamic area, whereas in the turbulent area the products themselves are less complex, although the logistics systems required to support them may be as technologically sophisticated as those in the dynamic area.

As our clients think about this issue, one question they always ask is: Can't one be a successful imitator? As Exhibit 5 shows, it has been possible to be a winner by being a fast follower. Examples include IBM with personal computers and Matsushita with video cassette recorders. Conversely, many innovators have lost out to their competitors. Nevertheless, in our view the imitator strategy will not be viable in the future. Most of the innovators who lost did so precisely because they had not mastered the art of rapid technological development. They had a single, wonderful innovation and then sat on their laurels, or in some instances did not even take their product to market.

Innovators must realize that competitors will rapidly copy the features of a given product. Nonetheless, being the innovator does give you a learning-curve advantage and therefore a cost advantage. In the case of a single innovation, that advantage rapidly dissipates. However, if a company can manage to innovate continuously, it can maintain a continuous cost advantage. Also, of course, it sets the scene for the consumer, thereby keeping competitors off-balance all the time as they watch to see what the next innovation is going to be.

Exhibit 3

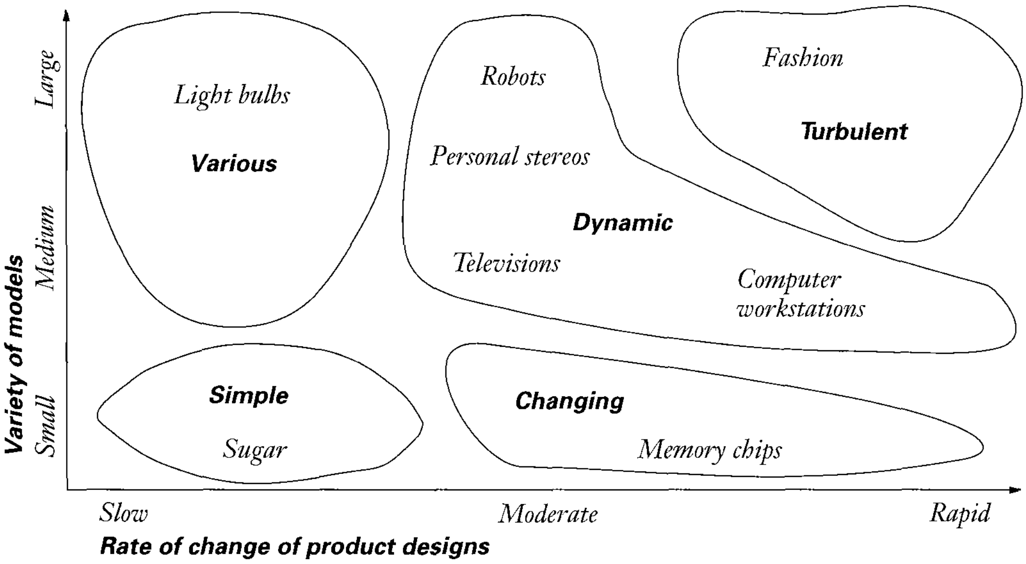
Declines in Predicted Model Life



Source: Sanderson & Uzumeri

Exhibit 4

Rates of Design Change versus Model Variety in Products



Source: Sanderson & Uzumeri

The work we have done at Arthur D. Little suggests that a firm's ability to achieve rapid technological development rests on five aspects of its performance: its strategy for innovation, its idea-generation and problem-solving, its product planning, its speed of execution, and its organization.

Strategy for Innovation. One of the critical choices in innovation strategy is whether to seek major breakthrough improvements or smaller, incremental innovations. Our answer is that in most cases, if you know roughly where you want to go, incremental innovation is faster and cheaper. Exhibit 6 diagrams two strategies for evolving a product technologically from start to finish. Strategy A takes four large steps, while Strategy B takes nine small steps.

Each step is an individual project that requires a certain time to complete. However, the relationship between project size and time-to-complete is highly nonlinear (Exhibit 7). As a project grows larger, more people are involved in it, and more communication, coordination, and time are required to complete it.

Exhibit 5

Innovation's Winners and Losers

	Innovator	*Imitator/follower*
Win	• *Pilkington (float glass)* • *G.D. Searle (Nutrasweet)* • *DuPont (Teflon)*	• *IBM (PC)* • *Matsushita (VHS video recorders)* • *Seiko (quartz watch)*
Lose	• *RC Cola (diet cola)* • *EMI (scanner)* • *Bowmar (calculator)* • *Xerox ("Star")* • *DeHavilland (Comet)*	• *Kodak (instant photography)* • *Northrup (F20)* • *DEC (PC)*

Exhibit 6

Large-Scale versus Incremental Innovation

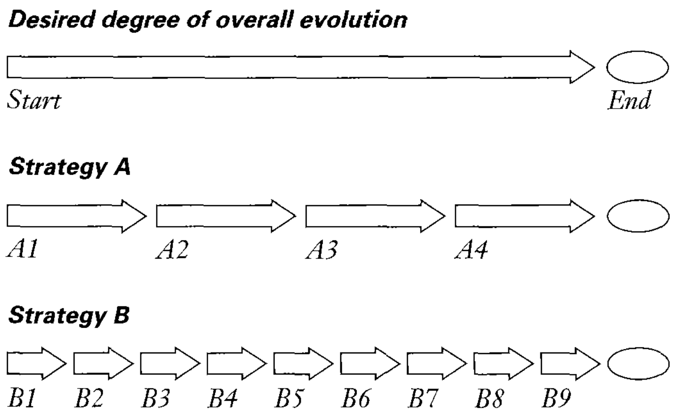
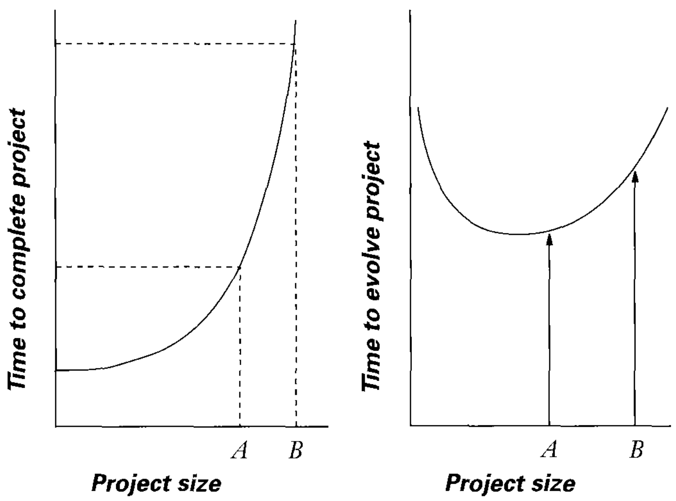


Exhibit 7

There is an Optimum Project Size



The right-hand side of Exhibit 7 shows the total time required to complete four consecutive projects of Size A and nine consecutive projects of Size B, respectively. It is interesting to note that there is an optimum size of incremental innovation for any given product in any given company. Most companies have tended to choose a size far to the right of the optimum, i.e., have tried to do too much in very large lumps.

Another facet of innovation strategy is the ability to focus on key components or technologies rather than on the end product itself. Examples are listed in Exhibit 8. Successful innovators identify key components and technologies and accelerate their development to the stage where product development groups can depend on them and incorporate them into the next generation of products. Not much money is spent on basic research, where, by tradition, information is so widely disseminated and commercialization so remote that there is plenty of time for imitators to catch up with front-runners.

This strategy of frequent, incremental innovation must be supported by a high frequency of product introductions, each incorporating a few technological innovations. Sony represents a good example of this strategy (Exhibit 9). Frequent product introductions not only permit R&D to be organized into small projects, which are inherently faster and less costly than large projects, but also offer a longer window of opportunity for introducing new technology. If a promising innovation cannot be incorporated into a given product introduction, no matter – there will be another one coming down the line in a few months.

Idea-Generation and Problem-Solving. The second area in which top-notch companies distinguish themselves is in generating ideas for what is worth doing in their products. These ideas become problems that require solutions. Top-notch companies also distinguish themselves in their approach to problem-solving.

Here is a test: Where do most good ideas come from? People often believe that most good ideas come from marketing, sales, competitors, or – in some companies – top management. In fact, statistical analysis reveals that the largest number of good ideas come from customers.

Customer-watching is absolutely essential if customers are to derive benefit from technology. Companies that do this well go far beyond the typical market research. They use the most advanced techniques, such as lifestyle analysis, perceived-value analysis, and concept testing, many of which were pioneered by consumer product companies.

Importantly, they insist that their technologists get out into the marketplace and talk to customers. The best features and functions in technological products often come from the intersection of technology know-how with customers' wants and needs. In contrast, traditional market research techniques obscure some of the most valuable information about customers.

Putting technologists in touch with customers in this way is quite different from the two most common approaches to technology development. The first of these drives technology into the product on the faith that someone will want it. The other, now fashionable in many industries in the United States, says „Customers don't want technology; let's go and find out what they want." The trouble is, customers don't know what they want in a vacuum. The intersection of what may be possible with what may be desirable determines what is worthwhile: technology that provides customer benefit. And the carriers of knowledge about what is possible are the technologists.

Because customer-watching is not infallible, leading-edge competitors also use a „let's try it" approach. For example, let's put a voice in each car that tells the driver that a door is ajar, or let's create a refrigerator with seven doors, and if customers don't like it, pull it off the market. This theory holds that it is better to be bold and venturesome than careful and parsimonious. Since there is a limit to the resources that can be squandered, however, such introductions are limited to innovations that can be grafted relatively cheaply onto existing products.

Part of what makes this method practical is that these companies have mastered the techniques for dealing with variety in their design, manufacturing, logistics, and customer-service systems. In addition, these companies are willing to try out any decent product that incorporates a key technology, partly in order to prepare the market for it, but mainly to smooth out production problems rapidly and without major financial risk. Thus, Kyocera-Kyoto Ceramics puts out ceramic-edged knives and scissors, not because it expects to make money from them, but because the production know-how gained through them is going to be invaluable for the eventual blockbuster products. In efforts such as this, technology development is driven all the way to the marketplace in a „test-bed" environment, so that all the problems of commercialization can be experienced on a small scale and dealt with.

The key point is that the first product to incorporate a new technology is viewed not necessarily as a profit-generator, but possibly as an extension of the company's technology-development activity. It is expected to pay for itself as part of research and development, not as a free-standing product.

Exhibit 8

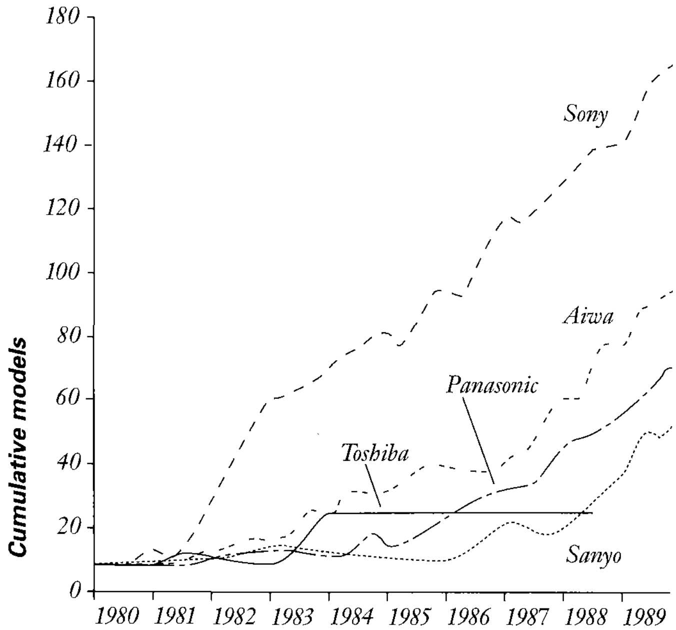
Focus on Key Components and Technologies

Feature	***Firm***	***Date***	***Marketing Insight***	***Imitated?***
„Walkman“	Sony	1979	Usage	Y
Mini headphones	Sony	1979	Usage	Y
AM/FM stereo radio	Sony	1980	Usage	Y
Stereo recording	Sony/Aiwa	1980-81	Usage	Y
FM tuner cassette	Toshiba	1980-81	Usage	–
Autoreverse	KLH SOLO	1981-82	Usage	Y
FM headphone radio	Sony	1981-82	Usage	Y
Downsized unit	Sony	1982	Usage	Y
Dolby	Sony/Aiwa	1982	Usage	Y
Direct drive	Sony	1982	Usage	–
Cassette-sized unit	Sony	1983	Usage	Y
Shortwave tuner	Sony	1983	Usage	–
Remote control	Aiwa	1983	Usage	Y
Detachable speakers	Aiwa	1983	Usage	Y
Water resistance	Sony	1983-84	Durability	–
Graphic equalizer	Sony	1985	Usage	Y
Rechargeable	Sony	1985	Usage	Y
Solar-powered	Sony	1986	Usage	–
Radio presets	Panasonic	1986	Usage	Y
Dual cassettes	Sony	1986	Usage	–
TV audio band	Sony	1986-87	Usage	–
Digital tuning	Panasonic	1986-87	Usage	Y
Child’s model	Sony	1987	Usage	–
Enhanced bass	Sony	1987-88	Usage	Y
Voice-activated	Toshiba	1988	Usage	–

Source: Sanderson sly Uzumeri

Exhibit 9

Frequency of Product Introduction



Source: Sanderson & Uzumeri

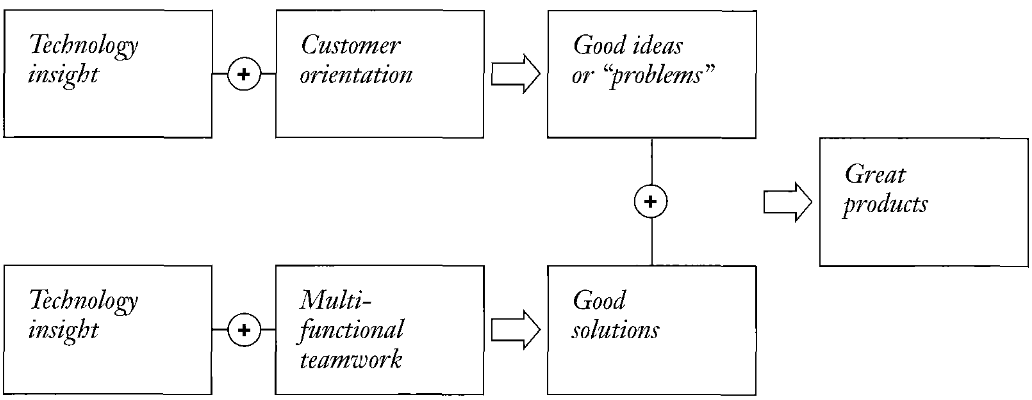
Here is another test: Where do most speedy solutions to problems come from? In our experience, engineers think speedy solutions come from engineering, and marketing people think they come from other places.

Our research suggests that speedy solutions to problems require two things: technology insight and multifunctional teamwork. You have to have the know-how to solve problems. And you need multifunctional teamwork – also known as organizational integration – because you have to have the additional know-how that can bring all of your know-how together to do problem-solving of the right kind.

Combining the optimal idea-generation process with the ideal problem-solving process produces a simple model for effective product innovation (Exhibit 10). The model says that if you have technology insight, multifunctional teamwork, and customer orientation throughout the organization, you get a combination of good ideas – or problems together with good solutions – and that's the starting point of great products.

Exhibit 10

A Simple Model for Effective Product Innovation

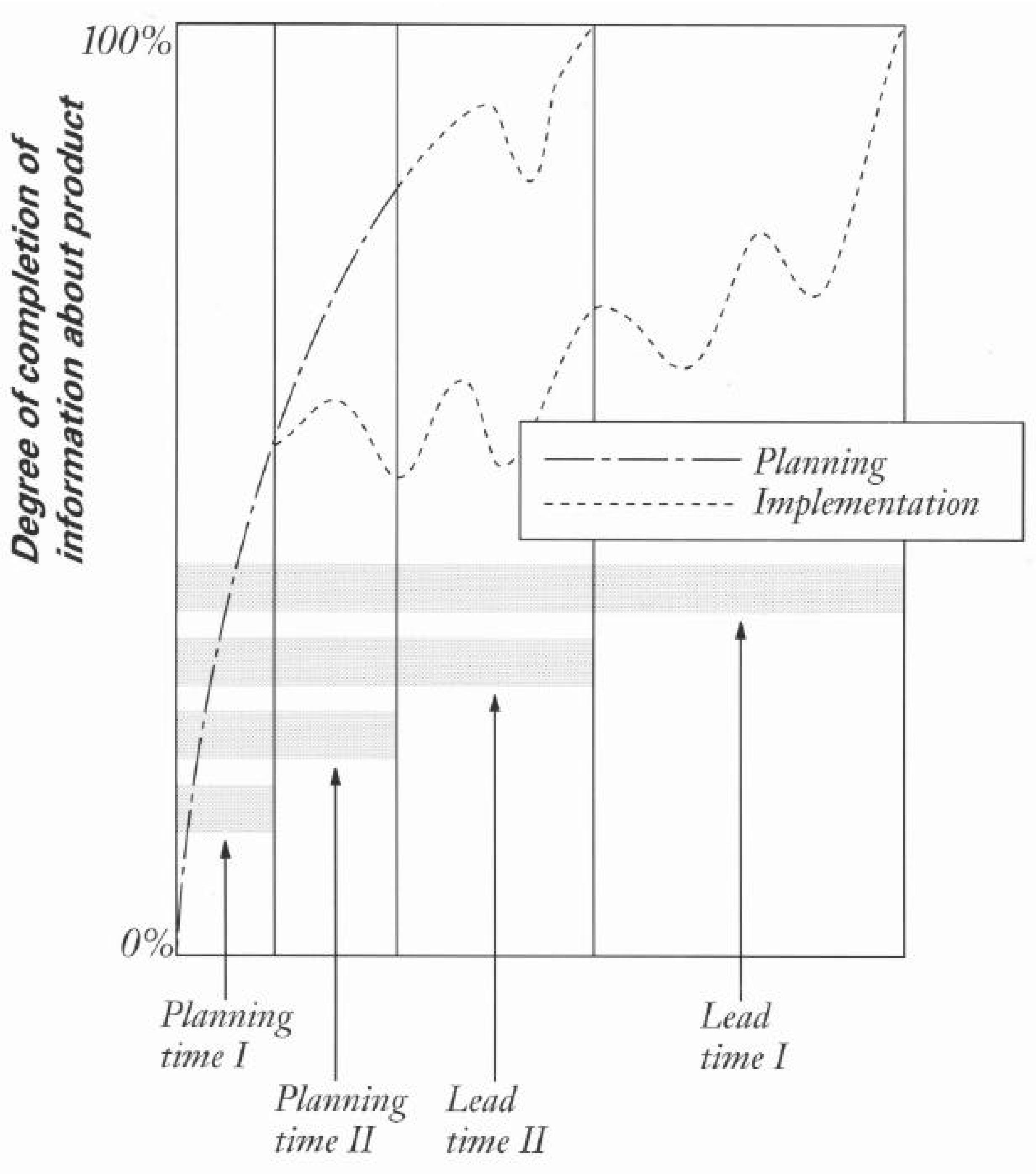


Effective Product Planning. A third area that technologically superior companies emphasize is the quality of their product planning. In most walks of life where planning is possible, good planning is absolutely crucial and necessary. However, almost no one does it.

Exhibit 11 shows some of the time and cost benefits of superior planning by contrasting strategies for exe cuting a product development project. We measure the degree of completion of the project by how much of the information needed to manufacture, distribute, and service the product is available at any time. When 100 percent of the information is available, the project is complete.

Exhibit 11

Planning Speeds Execution and Reduces Lead Time



In Exhibit 11, Strategy 1 devotes relatively little time to planning, then proceeds to implement the project. Inevitably, the project requires several cycles of reversal because its managers have never thought through what they wanted, and so they have to re-think it.

In the second strategy, the project managers do sit down and think through in great detail exactly how they are going to do what they need to do.

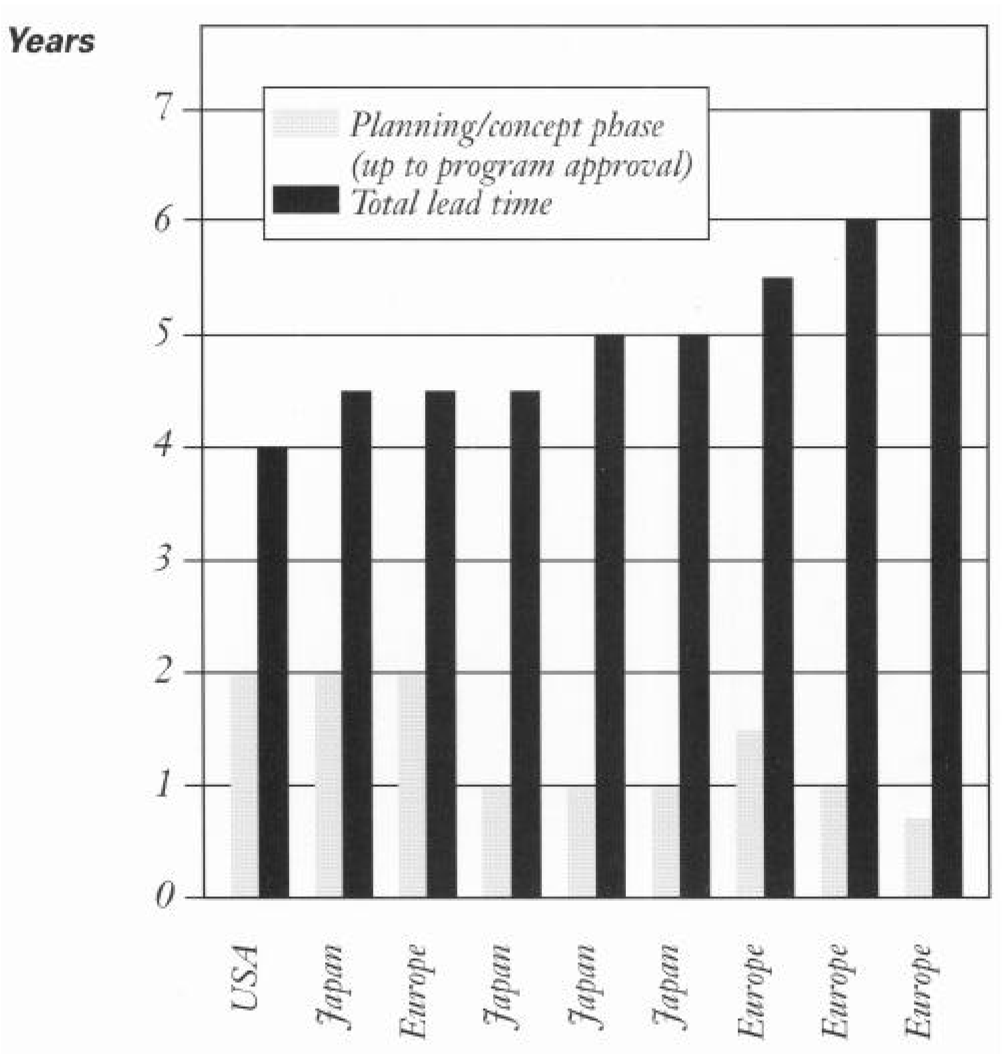
The interesting fact is that the more thorough the planning, the faster the implementation phase proceeds. In fact, a well-executed strategy can cut lead time by 50 percent.

Now, this relationship has an interesting effect on cost. Because planning is an intellectual phase, relatively few people are involved in this aspect of the product development process. Implementation, on the other hand, requires a very large number of people and considerable capital investment. Therefore, by lengthening the planning period and at the same time cutting back the implementation period, you reduce the costs of implementation tremendously and therefore save on the overall cost of the project.

For example, Exhibit 12 shows the results of a study we made of nine heavy-truck-development projects around the world. For each project, the bar on the right shows the time it took to complete the project, and the bar on the left shows how much of that was spent on planning. The inverse correlation between the two is striking. The American company whose project results are plotted on the far left completed a heavy-truck project in four years, of which it spent roughly two years in planning and two years in execution. In contrast, the European company whose results appear on the far right took seven years to execute a similar heavy-truck project, devoting less than a year to planning and then six years to repeated reversals of what the product was supposed to do.

Exhibit 12

Heavy Truck Development Projects

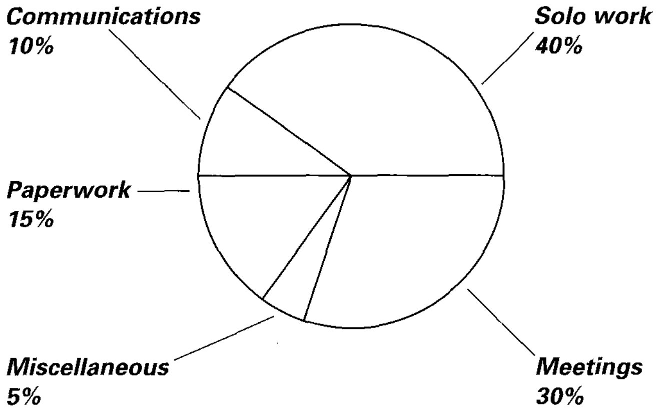


Speedy Execution. Nowadays, everyone wants to do things fast, and there's lots of merit in that. Many things help speed project execution, including good planning, effective use of productivity tools such as CAD-CAM systems, and working in parallel. A fourth critical factor in achieving speedy execution is appropriate allocation of the time of critical people.

We recently analyzed the use of time by engineers working on the critical path of a product development process (Exhibit 13). These engineers reported spending roughly 40 percent of their time on solo work, 30 percent in meetings, 15 percent on paperwork, and 10 percent in various forms of communication. We then probed a little deeper and discovered that of the 40 percent of time devoted to solo work, in the opinion of the engineers, 20 percent was valuable; 10 percent was rework (i.e., they had to redo what they had done before because the project changed direction, or they had the wrong information); and 10 percent was make-work, in which, essentially, they pretended to be busy when they had nothing else to do (Exhibit 14).

Exhibit 13

Use of Engineers' Time in an Automotive Company



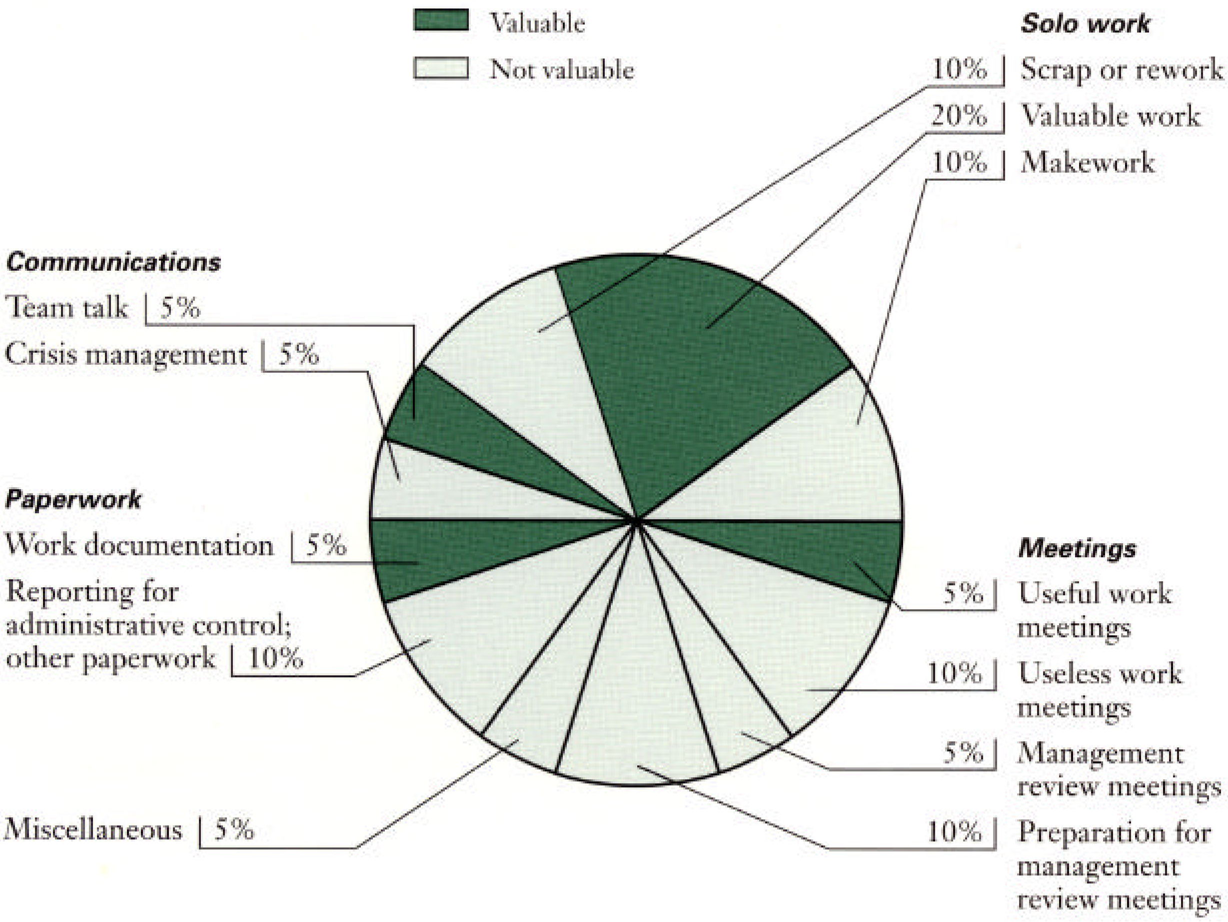
Of the 30 percent of time spent on meetings, 5 percent was described as useful team meetings or work meetings, 10 percent was useless team meetings, 10 percent was reporting to management, and another 5 percent was preparing for all those meetings. In short, these engineers felt that only 3 5 percent of their time was spent on valuable activities. Other studies, including some published by the Institute of Electronics and Electrical Engineers, suggest that some engineers report spending less than 10 percent of their total work time on valuable work. Clearly, if it were possible to raise the percentage of valuable work time from 10 to 30 percent to 70 percent or higher, considerably more time and talent would be available for product development.

Toward this end, it is interesting to look at the first-level causes of waste (Exhibit 15). We asked these engineers why, for example, 10 percent of their time in team meetings was wasted. They identified four first-level causes of waste: lack of a meeting agenda, lack of meeting facilitation, lack of knowledge of the topic among meeting members, and lack of authority for meeting members to make decisions.

Organization. The process of identifying first-level causes is tremendously valuable as a first step toward finding solutions. The next step is finding root causes. A root cause is something at the system level that needs to be improved and for which the solutions, though obvious, may require a significant commitment on the part of management. For example (Exhibit 16), we produced a tree diagram of the reasons that people have to wait for decisions. To elicit this information, we just kept asking „why?" A rule of thumb suggests that you have to ask „why?" five times before you get to a root cause. Root causes for waiting for decisions include inadequate training in the clear communication of alternatives, absence of a good model of teamwork, and a control-oriented management philosophy. As we do this kind of analysis, one root cause that often emerges is the lack of a good model of teamwork. In other words, people really don't know what a multifunctional team is or how it's supposed to work, yet effective teamwork and strong team leadership play an essential role in rapid product development. As Exhibit 17 suggests, there are strong correlations between the time a project takes and the level of authority the program manager has, the level of management he or she reports to, and the breadth of responsibility he or she has.

Exhibit 14

Analysis of Engineers' Time



It's clear that the traditional way of organizing, in which the program manager reports up within some functional area, is simply inadequate. Many product development projects require the delegated authority of the chief executive officer to confer on the team the power to make wide-ranging decisions involving financial tradeoffs, technical trade-offs, and so forth.

A successful team is an autonomous group of people with a passion for winning. Successful teams have certain common characteristics, such as a common purpose, clear objectives, dedication, a good game plan, finite tasks, and a strong leader. They also include differentiated roles for their members, to reflect people's varying skills and interests. But the team members are sufficiently multifunctional people to understand and even fill in for one another. Successful teams also have coaches, who can be outside the team and provide perspective and guidance. It is important for the organization sponsoring the team to provide both individual and team recognition. Finally, like championship basketball players, the team needs a „fast-break" mentality.

These are not impossible challenges. Many companies are successfully meeting them: Xerox, Motorola, Compaq, and Hewlett-Packard, to name a few. For those that succeed, it will be possible to achieve the ultimate balance: simultaneously satisfying customers, employees, and owners.

Exhibit 15

First-Level Causes of Waste

Activity	*Breakdown*	*Percent of total*	*First-level causes*
Meetings	Team	10%	• No agenda • No meeting facilitation • Meeting members uninformed • Meeting members have no authority
	Management	5%	• Control-oriented management style • No strong program manager • Previous disasters
	Preparation for management meetings	10%	• Hierarchical management style • Poor review process at lower level • Inadequate information systems
Other communications	Crisis resolution	5%	• Late errors • Blame-allocation philosophy • Poor problem-solving processes
Solo work	Rework	10%	* Specification change • Inaccurate information • Wrong design • Manufacturing problems
	Make-work	10%	• Waiting for input • Waiting for decisions • Poor work ethic • Poor supervision
Documentation	Administrative reporting and paperwork	10%	• Control-oriented management style
Miscellaneous	Coffee breaks, gossip, etc.	5%	• Poor work ethic • Poor supervision

Exhibit 16

Why People Have to Wait for Decisions

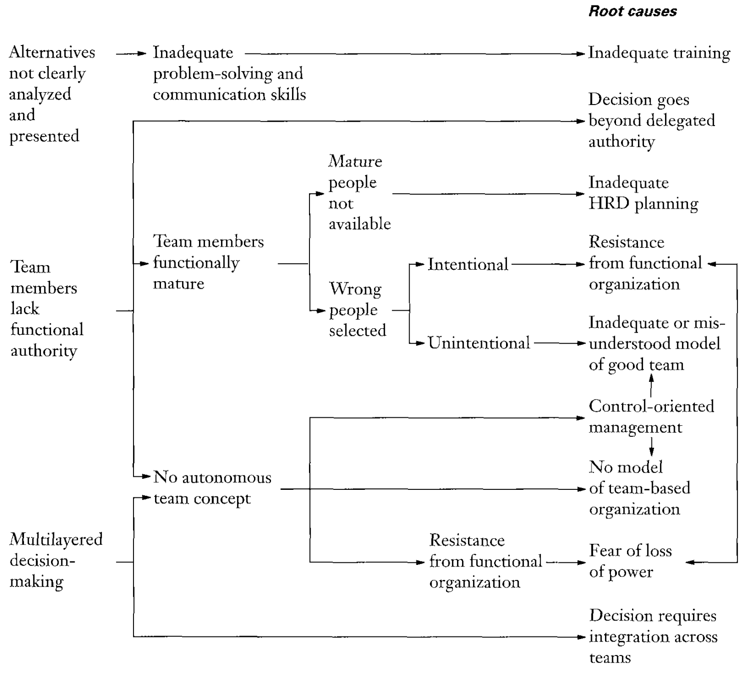


Exhibit 17

Companies With Strong Program Management Achieve the Shortest Lead Times

Truck company	*Average new-model lead time (years)*	*Exists*	*Program man structure*	*agement*	*Program mat process*	*lagement*
			PM reports to	*PM authority*	*PM leadership*	*PM responsibility*
A	4	Yes	CEO	High	High	Total program
B	4.5	Yes	CEO	High	High	Total program
C	4.5	Yes	CEO	High	High	Performance, cost, time
D	4.5	No		Functiona l	management –	
E	5	Yes	CEO	High	High	Performance, cost, time
F	5	Yes	CEO	High	High	Total program
G	5.5	Semi	Product planning	Moderate	Moderate	Performance, cost, time
H	6	No	----------- Project	managers	within functional	areas -------
I	7	No	----------- Project	managers within functional		areas ----------

P. Ranganath Nayak is a senior vice president of Arthur D. Little, Inc., and responsible for the company's worldwide consulting practice in operations management. He has extensive experience helping firms around the world improve their operations – particularly in the areas of research, development, and manufacturing.