

HOW TOYOTA DEFIES GRAVITY ITS SECRET IS ITS LEGENDARY PRODUCTION SYSTEM. THOUGH COMPETITORS HAVE BEEN TRYING TO COPY IT FOR YEARS, NOBODY MAKES IT WORK AS WELL AS TOYOTA.

By ALEX TAYLOR III REPORTER ASSOCIATE JEREMY KAHN

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(FORTUNE Magazine) – Two days a month, more than 50 automotive executives and engineers travel to a sprawling manufacturing complex in Georgetown, Ky., to learn how Toyota makes cars. The tours, which include an intensive question-and-answer session, last five hours and are booked months in advance. Although the visitors all work for competing automakers, Toyota charges them no money and places nothing off limits. Lately Ford and Chrysler technicians have been regular visitors to one of the two assembly lines, while General Motors personnel have demonstrated a particular interest in the powertrain operations.

Toyota's showing the opposition how it makes cars is a bit like Coke's giving Pepsi a peek at its secret syrup formula. The Toyota Production System on display at Georgetown applies not just to manufacturing but also to almost everything Toyota does, from product development to supplier relations and distribution. But Toyota officials don't mind. Deep down, they know that the TPS techniques that visitors see on their tours--the kanban cards, andon cords, and quality circles--represent the surface of TPS but not its soul. Toyota isn't worried about giving away any important secrets on a plant tour.

That may sound arrogant, but the evidence supports the conviction: Despite years of imitation, nobody has succeeded in displacing Toyota as the world's most proficient auto company. Mercedes-Benz may dazzle with its sophisticated engineering, Honda with its engine technology, and Chrysler with its styling. But Toyota sets the standard in efficiency, productivity, and quality. GM officials say Toyota is the benchmark in manufacturing and product development. A high executive at BMW whispers that, national pride notwithstanding, he regards Toyota as the best car company in the world. Another top executive, this one at Ford, says that Toyota is so far ahead in developing markets that the real race is for second place. Michael Cusumano, a professor at MIT's Sloan School and a member of the renowned International Motor Vehicle Program, who has written extensively about Toyota, says, "I don't know of a company that better combines superior skills in all the critical areas: manufacturing, engineering, and perhaps marketing. If they wanted to blow away GM, they could."

Though its competence has never been questioned, Toyota, the world's third-largest automaker (behind GM and Ford) as measured in unit sales, was long considered conservative and slow-moving. But under its aggressive and impatient president, Hiroshi Okuda, 65, who took over 30 months ago, it has become faster and sharper. "His message is speed, speed, speed," says senior managing director Shinji Sakai. You could have caught a glimpse of the new Toyota at the biennial Tokyo Motor Show in October. There, among the costumed mannequins called Toyota Pretties, Okuda showed off no fewer than ten experimental car models, more than any other manufacturer, as well as three new production cars. Said an executive from a rival European manufacturer: "This company just blows you away."

Signs of the new Toyota can be seen around the globe. Okuda is pushing Toyota to boost its market share in Japan to more than 40% from 38% currently, still way ahead of struggling No. 2 Nissan, which has 22%. Toyota also owns 21% of the market in Southeast Asia, nearly double the share of Mitsubishi, its nearest competitor. In the U.S., Toyota's Camry sedan has become the best-selling car for the first time, and Toyota ranks a solid fourth in unit sales behind the Big Three, with an 8% share. The only weak spots are Latin America, where Toyota is just getting started, and Europe, where it has struggled with weak products against entrenched competitors. Toyota is about to launch a new product offensive in Europe and announce the location of a second assembly plant there.

Toyota used to be a market-share monster that forsook profits for sales, but Okuda is changing that too. He wants Toyota to produce operating margins of 9% by the early 21st century, a big improvement over the 5.4% it made in 1996. Okuda also hopes to list Toyota stock on the New York Stock Exchange before 2000 and wants its financial statements to look more like its Western competitors' when he does. Some traditions die hard, however: Toyota still keeps \$21 billion in cash and short-term securities, a hoard that would make it an appealing takeover target in the U.S.

To hit Okuda's financial targets, Toyota will have to make a lot more money overseas, where it already earns about half its profits. But that will be harder than you'd think because TPS has one significant flaw: Like fine wine, it doesn't travel easily. Inside a plant, its success depends on highly experienced managers working unselfishly with a motivated, well-trained work force. Outside the plant, TPS requires a network of dedicated, capable suppliers that can run their operations completely in sync with Toyota's. For all its success overseas, Toyota hasn't developed a single facility that is as efficient as the ones it has in Japan. Says Wharton School professor John Paul MacDuffie, who has been studying the international automobile industry for more than ten years: "This is a difficult production system to take globally. But Toyota is working hard at it, and it is not clear anybody has a better answer."

Anyone want to read more about Japanese management techniques? I thought not. Last year's management fads are about as appetizing as yesterday's sushi, and ideas such as just-in-time inventory and continuous improvement feel shopworn, to say the least. TPS itself is hardly an unknown quantity. GM formed a joint venture with Toyota to study its production techniques back in 1984, and *The Machine That Changed the World*, which effectively anointed Toyota the world's productivity leader, was published in 1990.

But why is it, exactly, that nobody has been able to imitate TPS, much less duplicate its results? GM, Ford, and Chrysler have all borrowed bits and pieces, and Honda's system resembles Toyota's in many areas. But nobody has been able to match the master. "Even though TPS has been studied to death, it is not properly understood," says John Shook, an American who went to work for Toyota in Japan back in 1983 and now directs the Japan Technology Management Program at the University of Michigan. "Remember how Vince Lombardi always said he would share his playbook with anyone, but nobody could execute like the old Green Bay Packers? It is the same thing with Toyota. Everybody has techniques and practices, but nobody has a system like Toyota's."

On the surface, TPS appears simple. It can be explained with the kind of homilies that companies like to laminate on three-by-five cards: Maximize flow, eliminate waste, respect people. But while TPS in concept isn't complicated, its implementation and coordination require blood, sweat, and tears. Mike DaPrile, who runs Toyota's assembly facilities in Kentucky, describes it as having three levels: techniques, systems, and philosophy. Says he: "Many plants have put in an andon cord that you pull to stop the assembly line if there is a problem. A 5-year-old can pull the cord. But it takes a lot of effort to drive the right philosophies down to the plant floor. A lot of people don't want to give the needed authority to the people on the line who deserve it."

Adopting TPS means acquiring a different mindset. In most plants, for instance, workers try to overproduce because once they fill their quotas, they can take it easy. As a result, the flow of work proceeds in fits and starts. At Toyota,

overproduction is considered one of the worst forms of waste. The company designs the work to flow from process to process without peaks or valleys and still arrive in just the right quantity for the customer. That results in a smoother-running plant, and it keeps everybody busy. Says Shook: "TPS takes an incredible amount of detailed planning, discipline, hard work, and painstaking attention to detail."

To see TPS in action is to behold a thing of beauty. A Toyota assembly plant fairly hums: Every movement has a purpose, and there is no slack. Tour a typical auto plant, and you see stacks of half-finished parts, assembly lines halted for adjustment, workers standing idle. At Toyota the workers look like dancers in a choreographed production: retrieving parts, installing them, checking the quality, and doing it all in immaculate surroundings. Says DaPrile: "We believe in the four S's: sweeping, sorting, sifting, spick-and-span."

Adopting TPS requires a big leap of faith for any manufacturer. Since there is no stockpile of parts, suppliers and workers are under tremendous pressure to perform their jobs as scheduled and even to work overtime if they fall behind. A single weak link will hamstring an entire operation. When a Toyota supplier in Japan making brake valves was ravaged by fire in February, production was halted until 70 other suppliers took over production of the parts themselves. Deliveries were resumed within days.

Making imitation even more difficult, Toyota is always tinkering with its own system. In the early 1990s it introduced more automation into its factories, only to back away when the machinery proved too costly and inflexible. More recently Toyota has been trying to make jobs easier for its workers in the face of a persistent labor shortage in Japan. It now breaks the assembly line up into segments and allows workers to stockpile small buffers of unfinished parts at the end of each segment in case of an interruption.

This capacity to adapt is a fundamental, if seldom recognized, ingredient in Toyota's success. Takahiro Fujimoto, a Harvard Business School graduate who teaches at Tokyo University and has studied the company, says: "Toyota's real strength resides in its ability to learn. Its employees are problem-conscious and customer-oriented, and this preparedness is the source of the company's dynamic capability. The company's practices are constantly changing, even though its basic principles are unchanged." (For three graphic examples of how Toyota learned from its mistakes in the U.S., see box.)

The beauty of TPS is that its principles apply to other parts of the auto business, not just manufacturing. Like the plant floor operation, product development also requires leadership, teamwork, and communication. Says James Mateyka, the veteran A.T. Kearney consultant: "A lot of people view product development as an artistic achievement, but they are losing the race. It is not superior people; it is a superior system--a factory, really--and a culture that learns from mistakes. Toyota's strength is awesome. They can develop a car in 18 months or less, and they don't make the same mistake twice."

The way Toyota does that is by applying the principles of TPS. As Fujimoto and his collaborator, Kim Clark of the Harvard Business School, have written, effective product development requires not only creativity and freedom to produce innovative designs, but also discipline and control in scheduling, resource use, and product quality. Toyota treats a blueprint for a change order on an engineer's desk (or its electronic equivalent) the way it would an unfinished component. As long as it sits there, it is an impediment to completion of the job. Eliminate it or move it along, and you have improved the process.

Like everything else at Toyota, product development is changing too. In the early 1990s Toyota's system became so powerful that it generated more models with more options at higher prices than the market could absorb. So two years ago Toyota reorganized its engineers into three groups--front-wheel-drive cars, rear-wheel-drive cars, and trucks--to make it easier for different projects within the groups to share common components among themselves. Says Cusumano, who is completing a study of Toyota's product development system: "Toyota does a super job of balancing product integrity and differentiation with the economies of sharing components. It does it better than anybody."

The reorganization was led by Akihiro Wada, 63, executive vice president in charge of research and development. By forming the three groups, Wada effectively took power away from Toyota's legendary shusas, the omnipotent chief engineers who used to reign supreme over individual projects. Once considered the heart of Toyota's system, the shusas were blamed for contributing to the cost and complexity of new models by competing among themselves. In addition, says Wada, "the chief engineers tended to mimic what was already on sale rather than be creative. I like people not to be too concentrated on the voice of the market." Creativity is exemplified by the popular RAV4 sport-utility vehicle that Toyota introduced in 1994. Unlike every other SUV on the market when it was introduced, it is based on a passenger car chassis rather than on a truck's, so it is lighter and rides better.

Frighteningly for competitors, Toyota has ratcheted its product development up another notch. Most auto companies develop similar models sequentially. First you design a Camry sedan; then you design a Camry coupe. That lightens the engineering load and ensures that problems on one model get resolved before the next one is started. But Toyota has begun developing similar models simultaneously, so that the engineering tasks overlap. That enables the suspension team, say, to work on several different versions at once. Says Wada: "We urge people to look around at other projects to simplify the development process. They can learn from the failures and successes of each other." MIT's Cusumano believes that Toyota can save 15% in lead time and 50% in engineering hours by overlapping projects.

Under this new system, Toyota's product fecundity has been unrivaled. In the past two years it has introduced 18 new or redesigned models, including the new Corolla, which is made in different versions for Japan, Europe, and the U.S. Several Japanese models, like the Picnic and the Corolla Spacio, went into production as little as 14 1/2 months after their designs were approved--probably an industry record. Overall, Wada says Toyota has doubled its engineering output over the past four years while increasing its budget by only 20%--an astounding improvement.

Besides churning out new models, Toyota has been dazzling on the technology front. In December in Japan, Toyota will become the first automaker to sell a mass-production automobile with a hybrid engine. Called the Prius, it is propelled by an electric motor that gets its juice from both a battery pack, to get the car rolling, and a 1.5-liter gasoline engine that maintains it at road speed. Since the engine does less work, the Prius gets 66 miles per gallon and produces only half the normal amount of carbon dioxide. Toyota hopes to sell about 1,000 cars a month, but the Prius won't be profitable because it costs more than twice as much to make as the \$17,900 that Toyota is charging for it. Okuda is convinced that consumers in Japan and elsewhere are more interested in environmental issues than ever before, and he wants Toyota to be able to capitalize on the change.

Toyota also caught the auto world napping by announcing a breakthrough in engine design. The 120-horsepower engine in the 1998 Corolla uses 25% fewer parts than its predecessor, making it 10% lighter, 10% more fuel-efficient, and significantly cheaper. Toyota isn't releasing all the details, but it eliminated several brackets by molding them into the engine block, and it consolidated several electronic sensors. The changes, along with a very favorable swing in the yen-dollar exchange rate, helped Toyota slash the price of the '98 Corolla by an astounding \$1,500 compared with the '97 model.

Completing a technology hat trick, Toyota has declared a lead in the race to find an engine that will replace gasoline-powered internal combustion early in the 21st century. Okuda says Toyota is mobilizing all its resources to develop fuel-cell technology and will produce a car before 2005. Fuel cells generate electricity through a chemical reaction combining

hydrogen with oxygen and don't produce noxious emissions. Mercedes has already announced that it expects to develop a fuel-cell car within eight years, but Okuda is apparently determined to beat it.

No auto company can do everything by itself, and Toyota is more dependent than most on outside suppliers. On its own it produces just 30% of the parts that go into its cars, compared with about 65% for GM. Years ago Toyota made suppliers an integral part of TPS, often buying ownership stakes to seal the relationship. Just-in-time parts delivery, which Toyota pioneered, has now spread to other industries, but Toyota has deepened and enriched relations with its suppliers by thoroughly involving them in every facet of its operations. "Toyota realizes that its cars are only as good as the weakest link in its extended enterprise," says Jeffrey Dyer, an assistant professor of management at the Wharton School who studies Toyota's suppliers. "It has consciously institutionalized a set of practices for transferring knowledge between itself and the suppliers, so that the whole group learns faster."

More than any other automaker, Toyota in Japan benefits from cultivating suppliers in its own backyard. Dyer says that Toyota's independent suppliers are on average only 59 miles away from its assembly plants, to which they make eight deliveries a day. By contrast, GM's suppliers in North America are an average of 427 miles away from the plants they serve and make fewer than two deliveries a day. As a result, Toyota and its suppliers maintain inventories that are one-fourth of GM's, when measured as a percentage of sales. If GM were as efficient as Toyota, according to Dyer's calculations, it would save about \$500 million annually.

There's lots more to Toyota's supplier relations than proximity. "Some manufacturers ask, 'How can I club you into submission?'" says Byron Pond, CEO of Arvin Industries, which supplies exhaust systems and suspension pieces to Toyota and other automakers. "Toyota asks, 'How can I help you be better?'" To prepare Arvin to be a supplier, two Toyota engineers spent seven months in Arvin's Indiana plant, improving processes, materials management, and quality in preparation for a Toyota contract—even though the plant was then making parts for a competitor. "Toyota is an amazing company," says Pond.

For all Toyota's success with TPS in Kentucky and elsewhere, it remains a very difficult system to establish outside Japan. The smooth integration of manufacturing, engineering, and parts supply requires common purpose, static-free communication, and experienced management, all of which are found in greater quantities at home, where everyone comes from a common culture and speaks the same language. One U.S. engineer who watched Toyota at the California joint venture with GM, known as NUMMI, says TPS's success depends on the tireless work of up to 200 middle managers who spend three or four years in foreign assignments laying the groundwork. Successful as Toyota has been overseas, it hasn't been without a struggle, as Okuda observes: "The human relationships required for TPS may be peculiar to Japan and hard for foreigners to understand."

Toyota moves slowly into foreign markets. Typically it enters first by exporting cars into a country, then by welding them together in rudimentary plants from preassembled "kits," and finally by building the cars from scratch in a full-blown assembly plant. Toyota was only the third Japanese manufacturer, after Nissan and Honda, to build cars on its own in the U.S., and it did so only after experimenting at NUMMI. It avoids some markets entirely. After an unsuccessful venture in Mexico in the 1960s, Toyota left and has never returned.

Today Toyota makes about 30% of its cars overseas in 25 countries. But observers say that none of its operations work as well as the ones in Japan. "Even Toyota hasn't been able to duplicate its efficiency outside Toyota City," says MIT's Cusumano. "Their system is big, unique, and hard to duplicate. The U.S. plants are the best in North America, but they still take 30% to 50% more time to assemble a car."

One of the big problems is the lack of well-trained local managers. John Shook says that Toyota's Japanese plant managers typically have 20 years' experience in TPS, while local managers often start with next to none. The other big problem is suppliers. Says Hugh Patrick, professor of international business and director of the Japan center at the Columbia Business School: "As they go abroad, they can't have parts delivered eight times a day. They have to change some production procedures."

Indeed, for all its global ambitions, Toyota remains a very Japan-centric company. "It is still very hard to incorporate outsiders in their system," says James Womack, a student of TPS and the author of the recent book *Lean Thinking*. "In the long run, that will become a brake on their growth. You can't refer every decision back to Tokyo." Toyota's successful operation in the U.S. is essentially run from Japan. Instead of reporting to an American headquarters, the bosses of U.S. operations like manufacturing and sales are responsible to executives back in Japan. Partly as a result, turnover at Georgetown has been relatively high.

Okuda has declared that Toyota needs non-Japanese board members and adds, "We must develop managers regardless of their origins." Indeed, the company must. Okuda wants Toyota to be making six million vehicles a year sometime after the year 2000, up from 4.9 million last year. But with the Japanese market saturated and the country's economy stagnant, the auto market could shrink rather than grow. Nearly all of Toyota's future growth will have to come from overseas, and the company is clearly headed in that direction. When a new pickup truck plant is completed in Indiana late next year, Toyota will have four assembly plants in North America, with the capability to make 1.2 million vehicles. A fifth can't be far behind.

Given the condition of its Japanese base, Toyota has to proceed carefully. Okuda says he is gravely worried about the condition of the Japanese economy, which has been in a slump since 1990 and has contracted sharply this year. Southeast Asia looks a little shaky now too. Toyota's production in Japan has dipped from more than four million vehicles in 1991 to 3.4 million last year. It needs to make about three million annually to maintain its employment without laying workers off—anathema under Japan's lifetime employment system.

Okuda has a theory that companies can grow for 50 or 60 years but then go into decline as their technology becomes obsolete. He speaks from firsthand knowledge: Toyota has its roots in a 19th-century maker of automatic weaving looms. To prepare for the day when he believes the automobile will start to slide, Okuda is pushing Toyota to diversify into manufactured housing and telephones, which now account for about 10% of its revenues.

But given the importance of the automobile, it is hard to imagine a day when cars are not Toyota's core business. So as Toyota evolves from a multinational company into one that is truly global, TPS will have to continue to change too. There will be plenty of potholes, but TPS has surmounted most of them for the past four decades. Whether Toyota's competitors will start to figure it out is anyone's guess, but there are no plans yet to end the plant tours.

REPORTER ASSOCIATE Jeremy Kahn