SECTION 29
AUTOMOTIVE INDUSTRY[1]

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INTRODUCTION

The word "quality" has taken on new meaning in the automotive industry over the past two decades. No longer is quality simply a statistical scorecard on freedom from defects or the measurement of fit and finish. Today, quality has a much broader meaning that involves a customer's inner feelings about a product and the company that offers it.

The new definition of quality takes in the basics of performance, comfort, environmental suitability, and affordability, but it adds certain elements of what is known as "production quality", related to the maker's ability to perform consistently better, and "ownership quality", which deals with customer satisfaction.

[1]In the Fourth Edition, material for this section on the automotive industry was supplied by J. Douglas Ekings. In the Third Edition, material for the section on the automotive industry was supplied by Soichiro Toyoda.

Two other significant shifts have occurred in recent years to raise the level of quality and quality consciousness in the automotive industry. One is the industry's move to *anticipating* customer requirements rather than responding to them, as in the past. Increasingly, automakers have employed sophisticated demographic and other studies to learn more about tomorrow's consumer, whereas in the past the industry relied on comments from customers as information was gathered for product development.

The other important change is the increase in closeness between automakers and their key suppliers. In the past, suppliers tended to be treated as vendors and were selected mainly on the basis of price and delivery capabilities. Today, the industry's key component suppliers are nearly full partners with the major companies they supply, with both automaker and supplier reaching into one another's designs, plans, and quality-improvement mechanisms. This increased confidence, trust, and reliance serve to form shared-destiny relationships that are crucial to the improvement of quality in the automotive industry.

Historical Perspective of Automotive Quality. The automotive industry has grown from the days of hand craftsmanship into a complex infrastructure of the globally competitive automotive giants of today. Figure 29.1 reveals five eras in the growth of the automotive industry.

The earliest automobiles were built largely by hand, with each bearing as much quality as was put into it by a single craftsperson or a small group of them. Assembly was careful, time-consuming, and costly. The resulting quality was high, but expensive and inconsistent. Only the wealthy could afford a motorcar.

Henry Ford is widely regarded as the father of mass-production quality. He designed reliable cars that could be built rapidly, consistently, and inexpensively by people with less than master skills. Ford's vehicles met the consumer satisfaction requirements of the day, and America took to the road as ordinary families became able to afford automobiles.

Alfred Sloan advanced the concept of mass production but noted that consumers were raising the standard for customer satisfaction. He recognized that quality had begun to mean that a product had to meet customer expectations, not just a manufacturer's standards. Thus he created a great variety of motor vehicles, and his General Motors Corporation grew by offering cars for every purse and purpose.

Later came the rise of consumerism, followed by environmentalism, as will be explained.

Quality in the Automobile Business. There are three dimensions to quality in the automotive industry: quality in product, quality in production, and quality in ownership.

Quality in product is the product's overall ability to perform required functions. In the case of an automobile, this means certain performance capabilities, such as the ability to accelerate to 60 mi/h in a certain time; comfort and entertainment features, such as a quiet, smooth ride, controlled climate, and ergonomically designed components such as audio equipment; environmental acceptability, which means the vehicle is fuel-efficient, clean, and safe; and affordability, or meeting the customer's ability to pay.

Quality in production is the ability to produce consistent quality as designed while still meeting volume and cost targets. Within this important dimension are four functions. The first is production of a quality product, measured by defects per hundred. The second ensures operational quality, which

1. Traditional quality	Craftsman
2. Mass-production quality	Henry Ford
3. Customer satisfaction	Alfred Sloan
4. Rise of consumerism	Safety
5. Green movement	Conservation and clean air

FIGURE 29.1 Quality, historical perspective

is the plant's ability to introduce new models, remain flexible, and still maintain consistency. Efficiency is third and is the key to producing even higher quality as volume increases. The fourth production function is cost. The plant must be able to produce an affordably priced product at a profit.

Quality in ownership is the overall ability to satisfy customers throughout their ownership life cycle. This is a critical dimension of quality, but it is the one least understood. Ownership itself is the first function. In it, our progress is measured from the sales experience through each phase of initial ownership including trade-in and repurchase for all subsequent owners. It involves the quality of the purchase experience, the everyday use of the vehicle, service, repairs, and trade-in. Cost of ownership is another function, taking in everything from down payment and monthly payments through operating expenses, maintenance costs, and insurance, finally coming down to resale value. The third function involves the intangibles—the psychological value of this ownership experience. It is centered in pride of ownership, the owner's self-image, and other special feelings created by this relationship with a vehicle.

Industry Structure. The automotive industry has undergone a concentration that accelerated greatly in the postwar years. Today, the world has 65 international automakers, of which 22 compete in the United States. Under the pressure of cost and currency differentials and government urgings to balance trade, numerous international companies have opened manufacturing and assembly plants in the United States over the past two decades. Today, the United States is home to 61 passenger-vehicle assembly plants.

Design and Production. The cost of designing and manufacturing motor vehicles is very high, owing to the complexity of the vehicles, the rigid quality and safety standards involved in making them, plus the rigorous testing required and the frequency of design change. Thus design and manufacture are carried out in a very few very large companies. Increasingly in recent years, portions of the product design function have been shared by major automobile makers with their supplier companies. This sharing has added a dimension to the responsibility for quality assurance.

Marketing. Most manufacturers design and produce a variety of models in order to attract customers of varying means and tastes. Vehicles are sold through nationwide networks of franchised dealerships, some of which offer more than one manufacturer's products. Vehicle dealerships, most of which also offer used vehicles and service and repair facilities, numbered 22,650 in the United States as of January 1, 1998.

The External Climate. External factors began to affect the industry more and more in the postwar years. These include growing consumer activism, safety issues, product liability, government regulation, and the rise of environmental concerns.

Consumerism. As the automobile industry's annual-model cycle matured in the 1950s and 1960s, the opportunity for product improvement often was overlooked in the race to create change for its own sake—change more likely to involve fashion than function. Consumers began to resist this trend, demanding that vehicles meet quality standards not only at the time of delivery but throughout their lives and even at the time of trade-in. In this era of consumerism, automotive quality began to be measured over time.

Safety. Along with consumerism came new standards for safety. Many years after safety glass became standard in American automobiles, a great rush of safety-related improvements came to market, including advanced passive-restraint devices, antilock brakes, energy-absorbing steering columns, crumple zones, child safety seating, and stronger side-impact protection, among many others. Dealing as they do with the preservation of human life and limb, these improvements further raised the standard of quality required in automotive design and production.

Improvements that aimed to promote visibility, accident avoidance, and survivability in crashes were accompanied by some intended to ease the job of collision repair and to lower its cost. Certain safety improvements, notably passenger seat belts and other restraint devices, have proven to be successful in reducing injuries, and their installation is now mandated by federal law in the United States.

Product Liability. Manufacturers have been required to consider product liability, which has grown to become a serious concern, especially in the United States. It plays a significant role in product design and manufacturing. As consumers become more aware of manufacturers' legal obligations and the legal system encourages legal action when faulty product is the suspected cause of personal injury, automobile companies have had to become more cautious not only in product design and manufacturing but also in documentation communicated to consumers in association with their products.

Government Regulation. Government regulation has had a profound effect on the automobile industry. In the United States, the National Highway Traffic Safety Administration (NHTSA) regulates federal safety requirements that can affect design, cost, and consumer expectations of vehicles. Government regulations also mandate certain fuel-efficiency standards for motor vehicles sold in the United States. Although it is difficult to estimate the cost of compliance, increasing NHTSA mandates and other controls have tended to increase manufacturers' costs and vehicle prices significantly.

Environmental Issues. Two factors combined to create the green movement: One was the development of uncertainties in the world's fuel supplies; the other was worldwide recognition of the problem of air pollution. Following the oil crises of the midseventies and early eighties and the rise of air pollution to unhealthful levels in many of America's largest cities, the industry no longer could overlook fuel efficiency and exhaust emissions in its measurement of quality. All manufacturers of motor vehicles sold in the United States now operate under federal laws mandating increases in fuel efficiency and decreases in emissions.

Concept of Quality Assurance. The concept of quality goes beyond just meeting customer expectations and fitness for use, as has been explained. This concept extends to serviceability, costs, and emotional issues and remains until the eventual disposal of the vehicle at the end of its useful life. Toyota employs a system, illustrated in Figure 29.2, that also is characteristic of those in most automobile manufacturing companies.

This system for quality assurance was developed in Toyota Motor Corporation along with the company's renowned Toyota production system, to which it is closely tied. As standardization of product and process became the keys to consistent, high-quality production, certain communication disciplines became the keys to quality assurance. These were centered in the steady feedback of information from audits, inspections, testing, and analysis throughout the process of creating and producing vehicles.

Flexible manufacturing based on consumer preferences became the norm. Prior to this, the industry built huge banks of vehicles not to customer requests but on a push system of factory capacities. These changes, and inventory reductions that accompanied the lean-production, just-in-time philosophy, have radically altered production activity.

Lean Production. Several aspects of the Toyota production system combine to create what is known as "lean production", a concept now widely emulated by American automobile makers. Lean production involves the removal of waste from every step in the production chain—waste of energy, motion, time, and resources. It is based on the pull-through method of inventory control that Toyota's Taiichi Ohno devised in the 1950s, now known as "just-in-time".

Through training and partnering with suppliers, extensive cost reductions have been experienced by both manufacturers and suppliers as they order, build, and ship materials and vehicles on a pull-through or customer-demand system. With inventory reduction, hidden quality problems surface quickly and must be addressed immediately. This is often referred to as "lowering the water level," which will expose rocks (or problems) previously unknown or concealed. In this way, lean production yields important quality-assurance benefits.

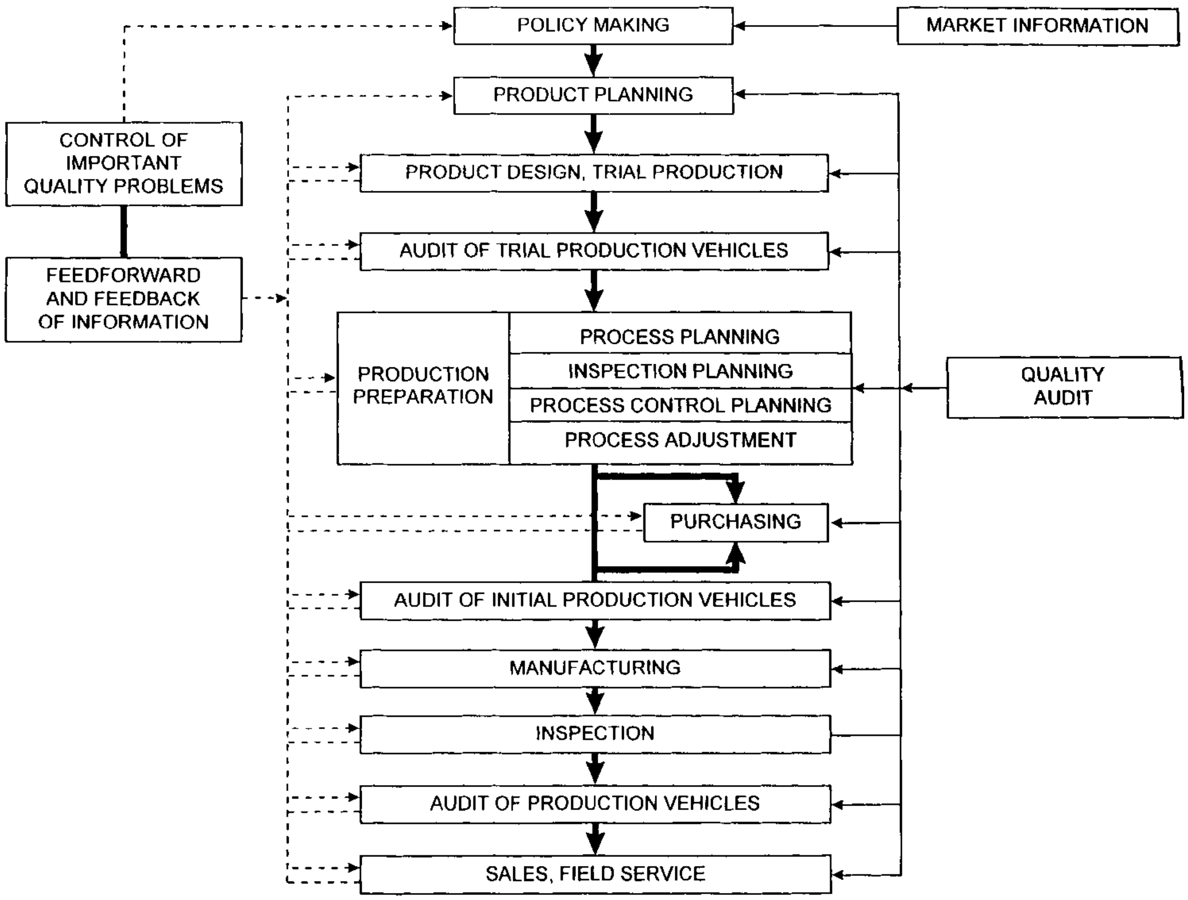

FIGURE 29.2 Toyota concept of quality. (*Toyoda, Soichiro. Automotive Industry 3d ed.*)

PRODUCT PLANNING

As increased consumer awareness and demands added fuel to the competition between growing automobile companies, product planning needed to follow the improvements in mass-production systems. As production systems improved and frequent major or minor model changes were required for competitiveness, the time required for new model planning and launch had to decrease. Thus the concepts of chief engineer, product platforms, and simultaneous engineering became the norm for all companies.

In Toyota, the chief engineer concept meant one person led a team of experts from various disciplines to plan and launch a vehicle in an efficient and effective manner. As the leader, the chief engineer must organize human resources and facilitate discussions to solve complex issues and ultimately is responsible for the success of the vehicle. To design and produce vehicles efficiently, the chief engineer is encouraged to use common parts and to look at class distinction in regard to vehicle content. Focus is also placed on engineering capability and assembly simplicity.

In the United States, many companies employ a platform concept that has radically improved both the quality and efficiency of the development process. Further steps are being taken to streamline timing and personnel efficiency to improve competitiveness.

The once-normal 36-month lead time for product planning and launch is no longer acceptable. Using the chief engineer and platform concepts, Chrysler and Toyota have achieved 23- to 28-month launches. The new target at Toyota is 18 months—half the historically acceptable norm. Shortened lead times also support customer-satisfaction improvements because they permit the timely response to economic circumstances and customer preferences that can change over periods of less than 3 years.

Figure 29.3 shows a typical approach to new model planning based on the 3-year term that was once normal in the industry.

Time-Phased Planning. The initial step in long-range planning is market research. To illustrate consumer buying trends, Figures 29.4*a* and 29.4*b* show research for customer vehicle purchase patterns. New model proposals set parameters to further define vehicles for the detailed planning phase. Parameters include the vehicle type, such as sedan, coupe, or station wagon; vehicle specifications for function, performance, reliability, service, and maintenance; timing for development; and cost and finance items, including selling price and profit.

Critical Quality Problems. An important step in the new model proposal is defining critical quality problems that must be addressed. This step is illustrated in Figure 29.5. The design group must provide data to support this activity and track its timely completion.

Design Planning. The design planning phase includes development of detailed specifications of components and their interface with major body/frame dimensions that are concurrently being developed. Drawings are developed, and consideration is given to historical data on like-vehicle development/manufacturing to "design in" foolproofing or elimination of such concerns.

Design Review. The design review phase is a critical step in the design process. A cross-functional team representing all disciplines reviews the design in detail. The team verifies and identifies safety and critical characteristics to ensure that specifications are clearly defined and that

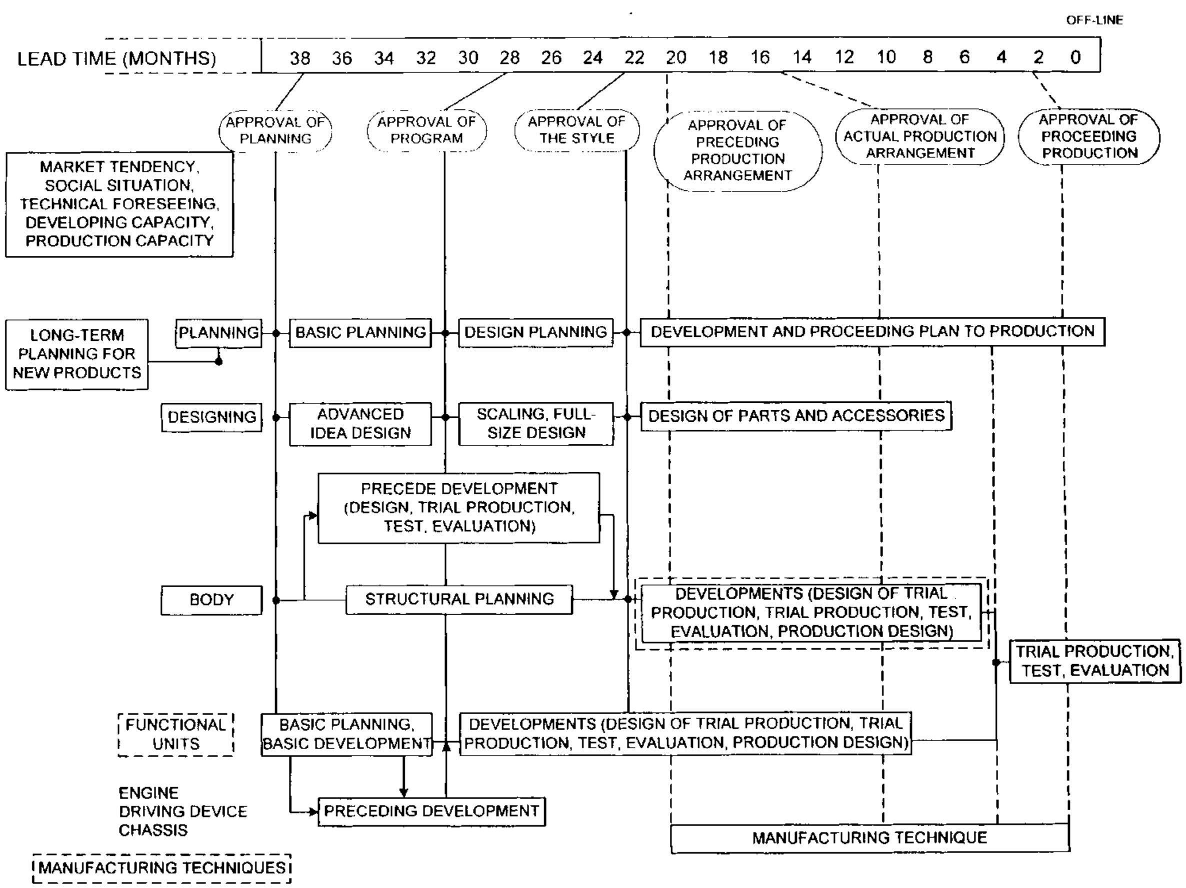

FIGURE 29.3 Product planning activity timing. (*Toyoda, Soichiro. Automotive Industry.*)

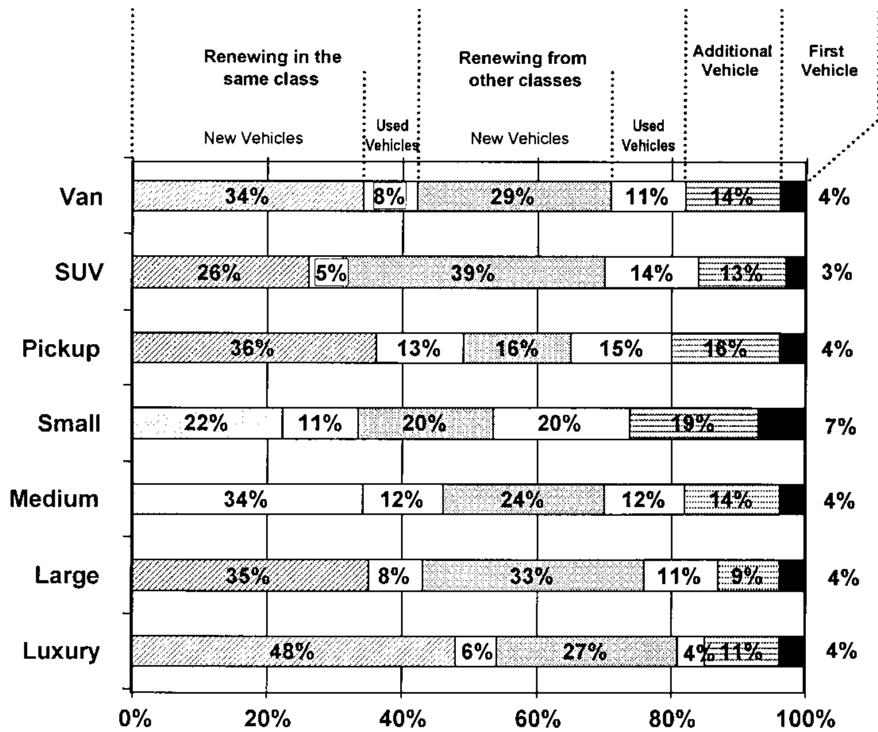

FIGURE 29.4*a* Customer vehicle purchase patterns. (*1996 Toyota New Buyer Survey.*)

Type	Replaced Vehicle: Same Class, Bought New	Same Class, Bought Used	Different Class, Bought New	Different Class, Bought Used	Additional Vehicle	First Vehicle	Total
Van	30	10	32	13	14	1	100
SUV	20	5	43	17	14	2	100
Pickup	36	15	17	16	15	2	100
Small	23	11	21	23	17	5	100
Medium	30	8	30	15	13	3	100
Large	34	6	38	10	10	2	100
Luxury	48	7	28	4	12	2	100

Note: Owing to rounding errors, numbers in row may fail to total 100.

FIGURE 29.4*b* Customer patterns of vehicle purchase (in percent). (*1996 Toyota New Buyer Survey.*)

all supporting functions comply with specifications. Marketing and practical aspects are also evaluated. Consensus must be reached to ensure that all activities and input are in line with the overall plan guidelines. The effort required to identify and address issues early in the design phase can save tremendous costs and delays later in the program.

Laboratory Testing. Laboratory testing during the design and prototype phase is important for all new products, materials, new or changed tooling, or new suppliers. With supplier participation in such testing, critical characteristics pertaining to function, durability, environmental conditions, simulated driving conditions, and crashworthiness can be measured prior to part finalization.

Evaluation under Actual Conditions. Prototype parts can be tested on current vehicles, either under test-track or actual road conditions, to obtain data that do not depend solely on laboratory

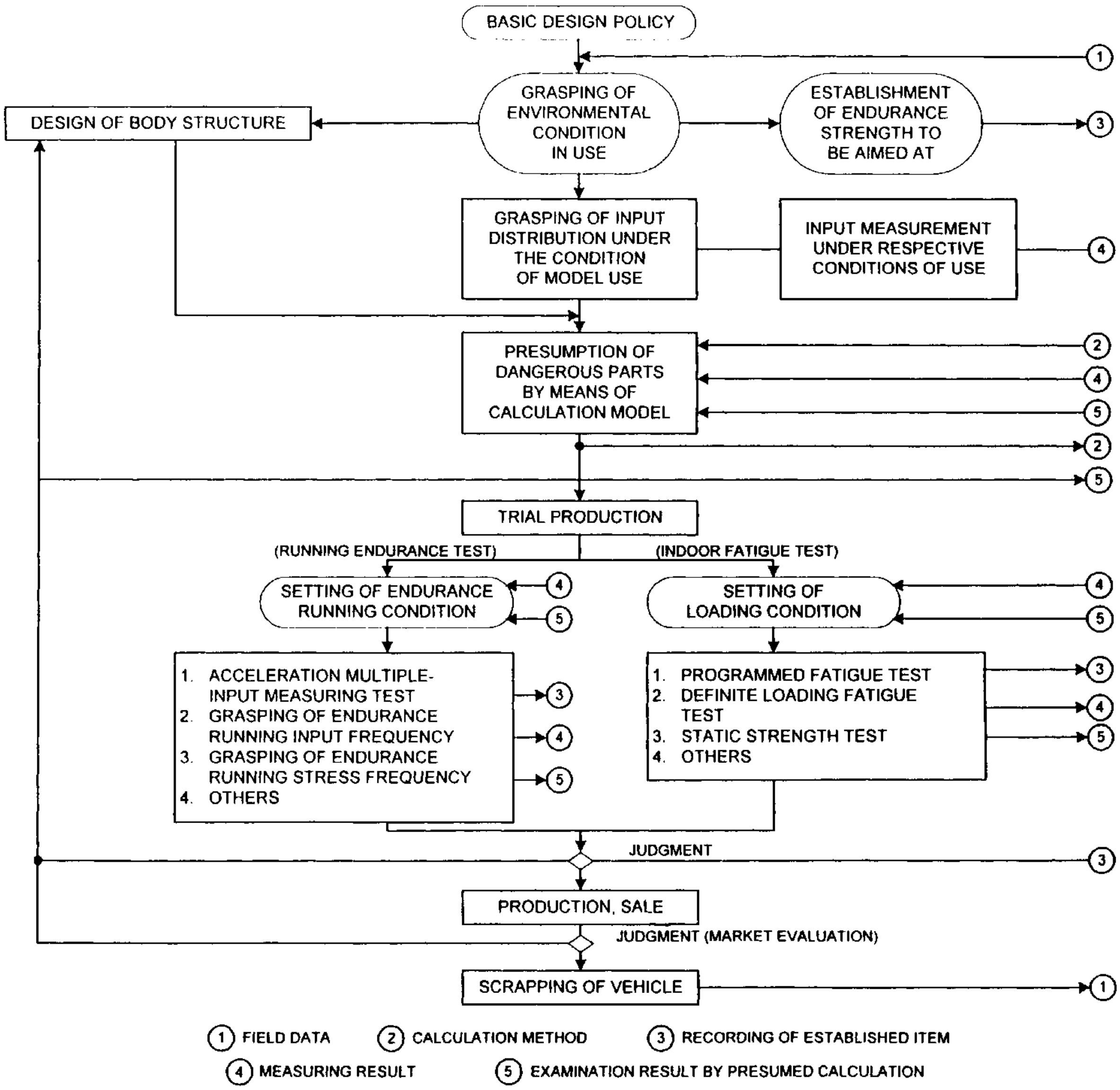

FIGURE 29.5 Idea model for body strength. (*Toyoda, Soichiro. Automotive Industry.*)

tests. This activity is important to warranty or long-term durability design activities. By incorporating this activity into customer-fleet or employee-fleet use, companies can collect extensive data on real-time use that may include extremely severe conditions and use, as with taxi or delivery-vehicle fleets. This testing may occur prior to release of the production part to all customers or in preparation for a product enhancement in the future.

Safety Evaluation. Individual components and completed vehicles are tested exhaustively to ensure the greatest possible protection for occupants. Various means are used to test components in the laboratory. Vehicle testing will be done to measure the effects of head-on, barrier-impact, rollover, and side-impact crashes, as well as the latest testing that includes variations of head-on impact at differing angles. Much of this information is used to enable insurance companies to calculate the cost of repair of a damaged vehicle and to establish facts on which to base safety-oriented advertisements.

Overall Evaluation. Constant feedback and communication are critical to the success of the design review, laboratory, and usage testing activities. Figure 29.6 depicts the steps of the feedback process that supports such activity. In this process, the more communication, the better.

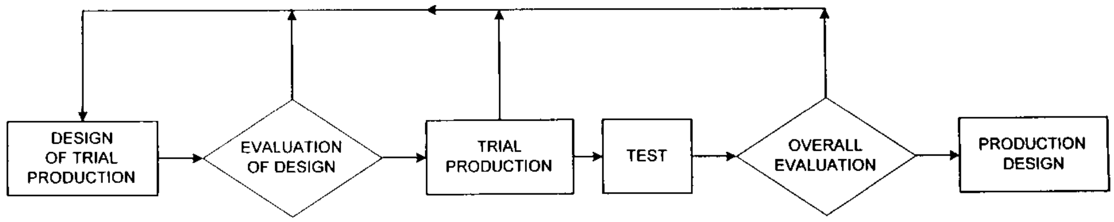

FIGURE 29.6 Design evaluation communication system. (*Toyoda, Soichiro. Automotive Industry.*)

Preparation for Production. As in the planning phase, production personnel are represented on the cross-functional team to support preparation for production. This phase directly supports the vehicle launch activity. Production personnel will help coordinate pilot production either at a separate facility or at the production line. As pilots are run, information is gathered to assist with the ramp-up to full scale. The participants may be the people who will train production-line workers. Others who will later be assigned as trainers may participate as well. The point of this activity is verification of issues such as the production process, tooling, and quality-control parameters.

Organization for New Model Planning. The organization supporting this activity varies not only by company but by model and complexity. The larger the company and more complex the change, the larger is the group and the number of departments. Normally, coordination of such activities can be provided by

1. Planners assigned full time to specific models
2. Task forces or committees with assigned representatives to facilitate communication
3. Formalized plans written to encompass all groups and required support
4. Process and procedures such as sign-offs

SUPPLIER MANAGEMENT

Supplier support and supplier partnerships become increasingly important in a lean-production environment. (See Section 21: Supplier Relations.) Gone is the day of the adversarial relationship between automobile manufacturers and suppliers. While the Japanese companies have practiced supplier partnerships for years, Chrysler and Ford are fast approaching the same practices. By developing trust between manufacturer and supplier, many mutual benefits can be achieved.

Supplier Relations. The component-supplier community can be immensely helpful to the automobile manufacturer in providing design expertise. If the manufacturer provides performance specifications to the supplier, leaving the component company to proceed with design, costs to the automaker can be sharply reduced. To support this activity, the manufacturer must allow supplier representation in the early phase of vehicle development—a big step in the partnering philosophy. This also requires agreements to allow suppliers to invest in development costs with some assurance of being awarded the business. The other element of trust involves suppliers opening their books and sharing costing information to support the manufacturer's objectives.

This is not a short-term activity, and it requires a great deal of interface between the management teams of both the supplier and the manufacturer to develop the required trust and support. This cooperation is essential for long-term competitiveness in the automotive arena.

Partnerships have long been a strength of the Toyota system. Through its close relationship with Toyota, a supplier can become stronger and more efficient. Various Toyota groups share the Toyota production system (TPS) expertise with their suppliers. Toyota groups in the United States have been receiving TPS training from the experts at Toyota Motor Corporation in Japan, and the sharing of this knowledge with suppliers has proven beneficial, since Toyota has experienced outstanding supplier improvements. As an example, the following facts show one company's improvement experience after 2 years of working with Toyota on TPS implementation:

Finished goods inventory reduction	82%
Work-in-process reduction	59%
Plantwide productivity increases	32%
Quality index improvements	58%
Production lead-time reduction	74%

The overall improvement depends on the supplier's system at the beginning of the project, but experience has shown that results like those in the preceding example are not uncommon. This activity takes a great deal of time and requires a large commitment on the supplier's part. Actual monetary investments are normally small; training, research, and reorganizing efforts can involve substantial investments of time. All suppliers have benefited many times over from these investments.

Often taken for granted by manufacturers is the openness of two-way communications between supplier and manufacturer. In many cases, however, the supplier will not share thoughts in order to appear not to question the customer's decisions. In order for the partnership to work properly, the customer must depend on suppliers for honest feedback on design, processes, and any other issues that may affect the output of their partnership. For their part, suppliers are entitled to a fair hearing of their honest feedback.

Supplier Base Reduction. If suppliers are to believe that they will be rewarded for the commitment of resources to a customer's product development, they must be able to see an opportunity to capture a significant share of the customer's business. Often this means that the number of suppliers must be reduced. By reducing the number of suppliers, the manufacturer's staffing and support also can be reduced, thus lowering costs. The supplier list can be reduced in a number of ways.

1. *Tiering.* Using large, tier-one suppliers to supply completed assemblies, rather than just their components, improves production efficiency, material handling costs, and supplier interface expenses. The tier-one supplier establishes relationships with the other component suppliers and becomes the final design, development, and assembly point for the completed assembly.
2. *Exclusive contracts.* As partnerships grow, it becomes normal for some suppliers to develop specific parts, as long as they uphold their portion of the partnership. Communication lines, development expertise, and overall system understanding are critical to these relationships. In some cases, supplier representatives have offices and full-time employees located in the manufacturer's facility to support that activity.
3. *Outsourcing.* In many cases it can be more expensive and cumbersome for automobile manufacturers to continue producing various components in-house than to rely on external suppliers. If a manufacturer has aging facilities, outdated production methods, or dwindling expertise, it may make sense to join forces with a supplier who is an expert in production of a required component.

Supplier Selection. As new products, processes, and increased volumes begin to demand the addition of supply resources, certain criteria must be established for their selection. Supplier surveys may be performed by individual departments or, preferably, by a cross-functional team representing all disciplines to ensure that all aspects of the company's capability are considered. Many factors may be considered, such as

1. Previous experience with the supplier
2. Affiliated company experience (parent, sister, joint venture, etc.)
3. Reputation or recommendations of other companies

Quality Assurance by the Supplier. As with other supplier activities, communication is critical for both supplier and manufacturer to understand the supplier quality assurance activities. This begins with early supplier involvement in the development process. Once the product is agreed on, designed, developed, and prototyped, four basic steps are key to ensuring customer satisfaction with the product.

1. *Product approval*
   - ***a.*** Verification of understanding *and agreement on specifications.* The supplier must understand the manufacturer's expectations and be able to deliver timely production quantities consistently on that level. The supplier also must understand the broader system and know how each component fits into it.
   - ***b.*** Initial sample approval. Samples provided for testing must come from production lots, not from laboratory or prototype production, if production capability is to be measured properly. All systems require first-production-piece verification. The additional requirements for sample size, test requirements, and reporting format may vary, but the intent is that the supplier must use this process to verify that expectations for continuous mass production can be met. On completion of this activity, the supplier will submit the part and information to the manufacturer for review. If all criteria and expectations are met, the supplier is given formal, written approval for production to begin. Should a concern arise, it must be addressed immediately to ensure that the part meets expectations and that timing is not delayed.
   - ***c.*** Comparison of test methods. The approval process should include a check of the compatibility of test methods. The supplier should include the test data with the test certificate attached to samples, including any information about accelerated life testing and destructive testing. The supplier should be given the automobile company's test results in order to discover and correct any differences in testing techniques.
2. *Process review.* A common practice with new suppliers is to audit the production process prior to awarding business. Process reviews of current suppliers also are conducted periodically. During the audits, discussions are held on improvements based on a comparison with other suppliers and the experience of the auditor. Also, suppliers may have process improvements or changes that require approval or on-site review by the manufacturer. On-site supplier visits can be useful, since continuous improvement activities will strengthen the process, partnership, and product quality. It cannot be stressed enough that manufacturers should view this as an opportunity and a small investment in the future of the relationship. This activity also strengthens both companies and builds trust through face-to-face meetings. Should the supplier experience difficulty or need assistance with a process, the door should be open to contact the manufacturer and ask for help. Within the manufacturer's ranks, experts should be available to be dispatched to support the supplier. The supplier also may seek the assistance of outside consultants known to the manufacturer to be capable of supporting both process and management improvement activity.
3. *Feedback.* Communications between the automobile company and the supplier must be open, whatever the topic. The supplier should expect honest, fact-based feedback from the manufacturer. The better the information provided, the quicker and more responsive will be the supplier's reaction. This is a true test of both partners' ability to give detailed information and respond quickly with a detailed, concrete action plan. No production system is ever completely foolproof, so when a concern does arise, responsiveness and support are of the utmost importance.
4. *Continuous improvement, or kaizen.* The supplier's work force should be made to understand that simply maintaining the present level of quality is not enough and that constant effort must be applied in the pursuit of improvement. The manufacturer's quality assurance group can help spearhead continuous improvement throughout the supplier firm by making available trainers and training materials; fostering quality-improvement competition between work shifts, departments, and teams; meeting with supplier teams to discuss quality issues; and recognizing continuous improvement by means of on-site supplier award presentations. If managements of both the manufacturer and the supplier regularly demonstrate their wholehearted support of *kaizen* in these ways, associates are more likely to buy into team problem solving, quality circles, and other techniques for ensuring continuous improvement.

Controls on the Supplier. Automobile companies exercise control over suppliers in several ways. Some of these, such as the process of supplier selection, joint quality planning, and supplier quality assurance, take place before production. Others take effect after deliveries begin.

Acceptance Inspection. Initial quantities of components from mass-produced lots are subjected to random sampling for the first 1 to 3 months of production. If defects are found, sampling quantities are increased and action taken as needed. If random sampling indicates quality within agreed standards, sampling is reduced and finally ceases, with the automaker relying thereafter on the supplier's test certificates and periodic quality audits. At this point in the relationship, dual sampling is avoided, and the supplier takes on greater responsibility for both product quality and its proof.

Supplier Quality Audits. An annual review of a supplier's facilities is normally conducted to ensure that the supplier is adhering to federal requirements and quality control plans in system testing and document control activities. By contract, suppliers must notify manufacturers of process changes, so documentation and the actual process can be reviewed during the visit. The on-site visit will include many subjects, some of which are listed in Figure 29.7.

Supplier Ratings. A rating system encompassing various supplier activities can be used for quality-improvement activities and awards. The system may compare the supplier against expectations, previous performance, and other suppliers. As an example, a summary page from the Toyota quality alliance rating system, administered by Toyota Motor Sales USA, Inc., is shown in Figures 29.8*a* and 29.8*b*.

MANUFACTURING

Development of Manufacturing Methods. Over the years, substantial growth in motor vehicle production volume led to the automation of numerous production-line activities, with the result that the economics of production became more favorable. A corollary benefit—greater quality—was created when automated machines and associated transfer devices demanded improved uniformity of input components to maintain continuous production. Thus automation yielded not only greater productivity and better economic use of human resources but also improved quality.

This benefit continues to follow the increasing use of computers to guide design and manufacturing processes, since computers make possible far greater reproducibility and consistency—essential to quality assurance—than is possible with purely mechanical means.

Production Preparation. Automobile companies maintain departments that carry out the preparatory steps through which the production force can maintain the desired level of quality: facilities and process planning, and trial mass production.

Organization	Incoming inspection procedure
Quality control policies	Process deviations
Product identification	Supplier performance records
Lot ID and traceability	Cosmetic acceptance standards
Test procedures	Defective material handling
Test results	Supplier defect notification
Process flow diagrams	Drawing control
Engineering change procedures	Specification documents
Inspection standards	Specification deviations

FIGURE 29.7 Supplier audit subjects. (*Note:* This is not al all-inclusive list.)

Product quality	
Quality Assurance	20
Warranty	15
Operational quality	
Deliver	15
Mispack/damage claims	5
Purchasing	20
Product support	
Marketing	12
Program management	5
Technical development	8
Total points 100	

(a)

Category	Group	Department
Product quality		
1. Quality assurance	U.S. products	Supplier development
2. Warranty	Service/U.S. products	Warranty administration
Operational quality		
1. Delivery	Parts	Parts supply
2. Mispack/damage claims	Parts	Parts invoicing
3. Purchasing	U.S. products	Procurement
Product support		
1. Marketing	parts	Parts marketing
2. Program management	U.S. products	Program management
3. Technical development	U.S. products	Parts and accessory engineering

Note: Suppliers should direct all inquiries regarding any portion of the evaluation to their respective buyers.

(b)

FIGURE 29.8 (*a*) Supplier evaluation scoring categories. (*b*) TMS responsibility by scoring category. (*Toyota Quality Alliance Rating System, Toyota Motor Sales, USA, Inc.*)

Facilities and Process Planning. The process-planning step specifies operations to be performed, the tools and machines to be used, and other aspects of production technique. Included in this step is an examination of the quality capability of the process to see if it meets the tolerances and dependability specified in the design. For the production of components related to basic vehicle functions or safety, the most stable and foolproofed production and inspection systems should be used.

Trial Mass Production. When all is in readiness for production, trial mass production is carried out to confirm that quality standards continue to be met as volume production proceeds. The variability or dispersion of the product at all stages, from manufacture of parts through final assembly and testing as automobiles, is measured closely. Dispersion data can be used to identify any processes requiring improved uniformity. Trial mass production also helps to identify any required changes in tooling.

Process Control. The control of manufacturing processes becomes simpler with each addition of computerization in the workplace. Relying as it does on rapid feedback of information, process control is well served by computer processing of quality data. Some production functions rely on older, conventional processes subject to human variability and provide little feedback. In these, worker training and motivation become ever more important as production volumes increase.

The concept of process capability is in widespread use throughout the automotive industry. Because process capability can vary with process conditions, it can be useful to maintain a record of process capability and to investigate any significant variances, especially deterioration.

Operator process control and product acceptance empowerment also became popular in recent years. Equipped with information on quality standards, machine operators are being empowered to take greater control in regulating the process to meet standards. Operators also are being empowered to accept or reject product under the operator self-inspection concept. The operator decides whether the process should continue or stop and whether the product meets quality specifications.

Automatic process regulation takes the place of human judgment in many applications, relying on automatic measurement and feedback for regulation of processes without human intervention. Maintenance of such systems does require periodic human intervention, and inspections of the process capability lead to necessary repairs, adjustments, and replacements.

Process Improvement. Historically, industry has relied on engineers and supervisors to contribute changes to industrial processes. Worker contributions were limited to suggestion-box ideas and received relatively little recognition.

During the 1960s, Japanese industries launched extensive educational programs for workers at all levels on ways to control and improve processes. At Toyota Motor Corporation, such programs began in 1961 and included such matters as quality control, Pareto diagrams, characteristic factor diagrams, histograms, control charts, and correlation diagrams. Quality circles were initiated to foster improvement in intradepartmental processes, with remarkable results. A later campaign to eliminate defects and claims due to process deficiencies and operator error also was responsible for great improvements in quality.

Kanban. *Kanban* is one of the primary tools of the just-in-time system that is used to facilitate an even flow of production and an even distribution of work among the various stages of manufacturing and transportation. With thousands of items such as engine components, drive train parts, sheet metal pieces, seats, and other interior parts, *kanban* maintains an orderly and efficient flow of goods, material, and information throughout the entire manufacturing process.

Kanban is usually a printed card in a clear plastic cover that contains specific information such as part description, part number, and quantity or lot size. This card is affixed to the various containers, bins, and racks that hold the parts. These *kanban* cards are used to withdraw additional parts from the preceding process to replace the ones that are used. It is the concept of "sell one, buy one." In so doing, only the right parts are used, in the right quantities and at the right time. You might look at it as a waste-free means of producing and conveying materials.

INSPECTION

In-line and final inspectors have been an important part of automobile manufacturing for many years. The inspection operators review material, component, and assembly quality to ensure conformance to standards. Data provided by the inspection functions can facilitate product and process improvements to foolproof product quality. The information is used primarily for immediate operator feedback and machine adjustments. This information is used for reports to management for comparison and tracking purposes to support cost justification for machine, product, or process improvements. Management support can be directed to areas requiring improvement based on inspection feedback. This focus can greatly assist management, and the overall process will benefit. To a considerable extent, the role of inspector in some automobile companies has been taken by production-line operators as a part of the operator process control and product acceptance empowerment mentioned earlier.

Classification of Defects by Seriousness. The automobile industry has developed a widely accepted classification system, with three major groupings for all defects.

A. Safety or critical functions that can endanger operators or passengers or render the vehicle functionally inoperative, such as brake function, electrical operations, or steering.

B. Operations that affect primary functions of the vehicle or major appearance items that most customers would not accept, such as inoperative locking mechanisms; faded, chipped, or peeling paint; or noisy operation of engine or brakes.

C. A third category includes items that do not affect vehicle functions or appearance items not leading to customer complaints, such as crooked labels or stripes, underbody rust, or an inoperative glove box light.

Concerning customer satisfaction, *A* defects will be returned for repair, *B* defects normally will be returned, and *C* defects are almost never returned if they are the only issue found. This severity rating helps automobile companies focus on major issues.

Organization for Inspection. Incoming, in-process, and final inspections are the three types commonly used in automobile plants. Inspection methods are usually developed by each group to support customer satisfaction by focusing inspections based on product, process, and operator concerns. In many cases, formalized procedures requiring documentation must be tracked [e.g., Federal Motor Vehicle Safety Standard (FMVSS) requirements, or other safety items]. Many of these issues can be machine-verified, but issues that cannot be verified are 100 percent checked by inspection personnel. Other inspectors may do random audits of machine processes to verify that machine results and readings are accurate.

- *Incoming* checks are performed on raw materials or purchased components. Different testing requirements based on different raw materials must be developed based on hardness, strength, clarity, and otherfactors.
- *In-process* checks include items such as dimensional checks (stampings, machining, molding); equipment temperature, pressure, and timing (casting, forging, molding); fit verifications; and functional verifications. Major functional components such as axles, transmissions, and engines may be operated prior to final assembly to save repair time and costs should a defect be found.
- *Final vehicle inspection* is performed after all components are assembled and the vehicle is complete. Many functional checks, adjustments, and verifications are required. Based on vehicle complexity, some additional functional issues may need to be verified. A few of these are

Water test: Ensures leak-free vehicles

Front wheel alignment: Verifies toe, caster, and camber to ensure best handling and long tire wear

Brake function: Ensuring no leaks and that all components functioning

Headlight aim

Complete functional check

Prior to shipping, a complete appearance check is done to ensure that no damage, paint, or fit concerns reach the customer. Although most inspections are redundant or additional overhead activities, they are generally accepted as a requirement by automobile manufacturers to promote customer satisfaction.

FIELD SERVICE

Of concern to all automotive manufacturers are the sale and service of vehicles they produce. Since most vehicles are sold through independently owned dealers, manufacturers do not have direct control of this activity.

Role of the Dealer. It is the obligation of the dealer to deliver the vehicle in good, clean condition, with emphasis on satisfying the customer during the sale and beyond. Manufacturers spend a great deal of time, effort, and money to develop procedures to support dealer sales and service. Recognizing that these activities may be the only experience the customer has with the manufacturer other than vehicle performance, automobile companies provide extensive training for sales and delivery activities. This assists dealers to improve initial reaction and retain the customer for future sales. Training provided by the manufacturers for technical service of the vehicles is even more extensive than sales training. Certification programs have been developed for service technicians to create levels and competition among technicians. Manufacturers support sales and technician training with the hope and expectation of increased customer satisfaction as dealership personnel become better and stronger assets.

Vehicle Service System. During the warranty period, dealers are almost guaranteed that customers will return to the dealership for maintenance and warranty repairs, if required. Most of these charges are paid directly to the dealer by the manufacturer. Dealerships must satisfy customer needs during the warranty period in the hope that the customer will return to them for maintenance and repairs beyond the warranty period. By satisfying customers and creating ongoing business, the service area can be an excellent profit center for the dealership.

As the automobile manufacturers increase the warranty period and coverage of their vehicles, dealerships are guaranteed more service activity that can lead to increased after-warranty service. Figure 29.9 shows the initial maintenance log for a typical manufacturer. Dealerships have many sources of parts to use after the warranty period, but during the warranty, manufacturers require the use of original equipment (OE) parts. All manufacturers have extensive parts distribution systems to support dealer requirements for these parts in a timely manner. Toyota, for example, established its North American Parts Logistics Division to improve local parts sourcing and to serve as a parts distribution network supplying all North American Toyota dealers, export markets, and certain General Motors vehicles.

Once the warranty period has expired, the parts-purchasing option is open to the dealership. Since the OE parts have satisfied the dealer's needs and are competitively priced, the manufacturer urges the dealer to continue to use them. This supports the manufacturer by ensuring that

1. High-quality parts are used.
2. Specifications including fit and functions are correct.
3. Manufacturer's distribution systems are supported for ongoing activity.

The use of factory parts also will help support high customer satisfaction.

Feedback of Information on Field Quality. The performance of vehicles and parts in the field is information essential to the manufacturer. Not only is this information pertinent to continuous-improvement activity on current parts and future designs, it is vital to ensuring customer satisfaction. Safety concerns are normally monitored by government regulatory agencies such as NHTSA in the United States, and the manufacturer must communicate to the agency all pertinent activities to support the issue. On nonsafety issues, customer satisfaction is a major concern, and the way the recall campaign is handled can be critical to satisfying customers. Figure 29.10 shows a typical feedback system for manufacturers.

Field Service Beyond the Warranty Period. As repairs to customer vehicles are made during the warranty period, extensive information is required to support dealer payment. This information is extremely helpful for improvements to parts, decisions to launch a recall campaign to repair or replace defective parts, or setting realistic parts performance expectations based on actual field data. Figure 29.11 shows many of the inputs required to complete a warranty claim. The information is very similar for all manufacturers.

Manufacturers require that many of the parts being replaced be returned for teardown and analysis. Root-cause analysis using the "plan-do-check-action" (PDCA) model (Figure 29.12) can be performed by the responsible engineer and/or supplier using these returned parts. This information is much more useful than a written description of the technician's opinion.

Fleet Feedback. Vehicles in customer or automaker-employee fleets also are sources of information. With customer fleets, high mileage or hard use may accelerate the feedback obtained.

5,000 Miles or 4 Months*

☐ Replace engine oil and oil filter

Additional Maintenance Items for Special Operating Conditions:
Please refer to page 30 of this supplement to determine if your vehicle requires the additional maintenance items.

Inspect the Following:

- ☐ Air filter
- ☐ Brake: linings, discs/drums
- ☐ Steering linkages
- ☐ Ball joints and dust covers
- ☐ Drive shaft boots (re-torque flange bolts)
- ☐ Body/chassis nuts and bolts

Dealer Service Verification

Date: ____________

Mileage: ____________

10,000 Miles or 8 Months*

☐ Replace engine oil and oil filter

Additional Maintenance Items for Special Operating Conditions:
Please refer to page 30 of this supplement to determine if your vehicle requires the additional maintenance items.

Inspect the Following:

- ☐ Air filter
- ☐ Brake: linings, discs/drums
- ☐ Steering linkages
- ☐ Ball joints and dust covers
- ☐ Drive shaft boots (re-torque flange bolts)
- ☐ Body/chassis nuts and bolts

Dealer Service Verification

Date: ____________

Mileage: ____________

7,500 Miles or 6 Months*

☐ Replace engine oil and oil filter

Dealer Service Verification

Date: ____________

Mileage: ____________

* Use the white background boxes to follow 5,000 mile oil change intervals or the shaded background boxes to follow 7,500 mile oil change intervals. Please refer to page 29 of this supplement for further information and to determine which interval is right for your driving circumstances.

5,000 Mile Oil Change Intervals

7,500 Mile Oil Change Intervals

FIGURE 29.9 Maintenance log.

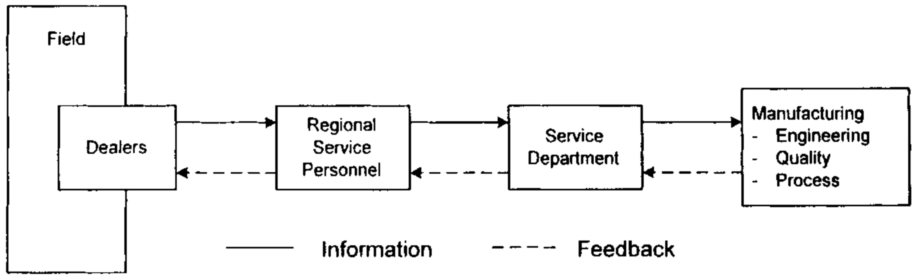

FIGURE 29.10 Feedback.

Car line	Delivery date
Model year	Sales district
Assembly plant	Repair date
Serial number	Mileage at repair
Body style	Part number
Engine type	Defect code
Transmission type	Vendor code
Axle ratio	Cost of repair
Month of production	

FIGURE 29.11 Warranty input information.

With employee vehicles, prototype or improved parts can be tested to verify effectiveness of the changes.

Customer Complaints. All manufacturers have toll-free telephone service for customers to gain information and assistance or to voice complaints. In many cases, this information can be used to support product or process improvements. Also, quick reactions by the appropriate individuals can ensure the maintenance of high customer satisfaction. The overall goals of this activity are improved product quality and increased customer satisfaction.

QUALITY AUDIT

As an additional check prior to shipping vehicles to customers, manufacturers do random-sample vehicle audits. Although many audits take place in-plant, analysis of the final assembled vehicle can verify product and process quality throughout the entire production system. The final vehicle audit is broken up into various areas.

Specification. This includes torque tests of various fasteners, verifying component correctness, function tests for setting within specified ranges such as parking brake or shift adjustments, air-conditioning function, and a leak test.

Customer Acceptance. This includes fit, finish, and function.

Road Test. Driving vehicles measures noise, vibration, harshness (NVH) issues and functional or dynamic problems such as front end or wheel balance.

Water Test. Ensures that all sealing areas are complete. Issues found in these areas are immediately referred to root-cause analysis and countermeasure development. The final vehicle audit

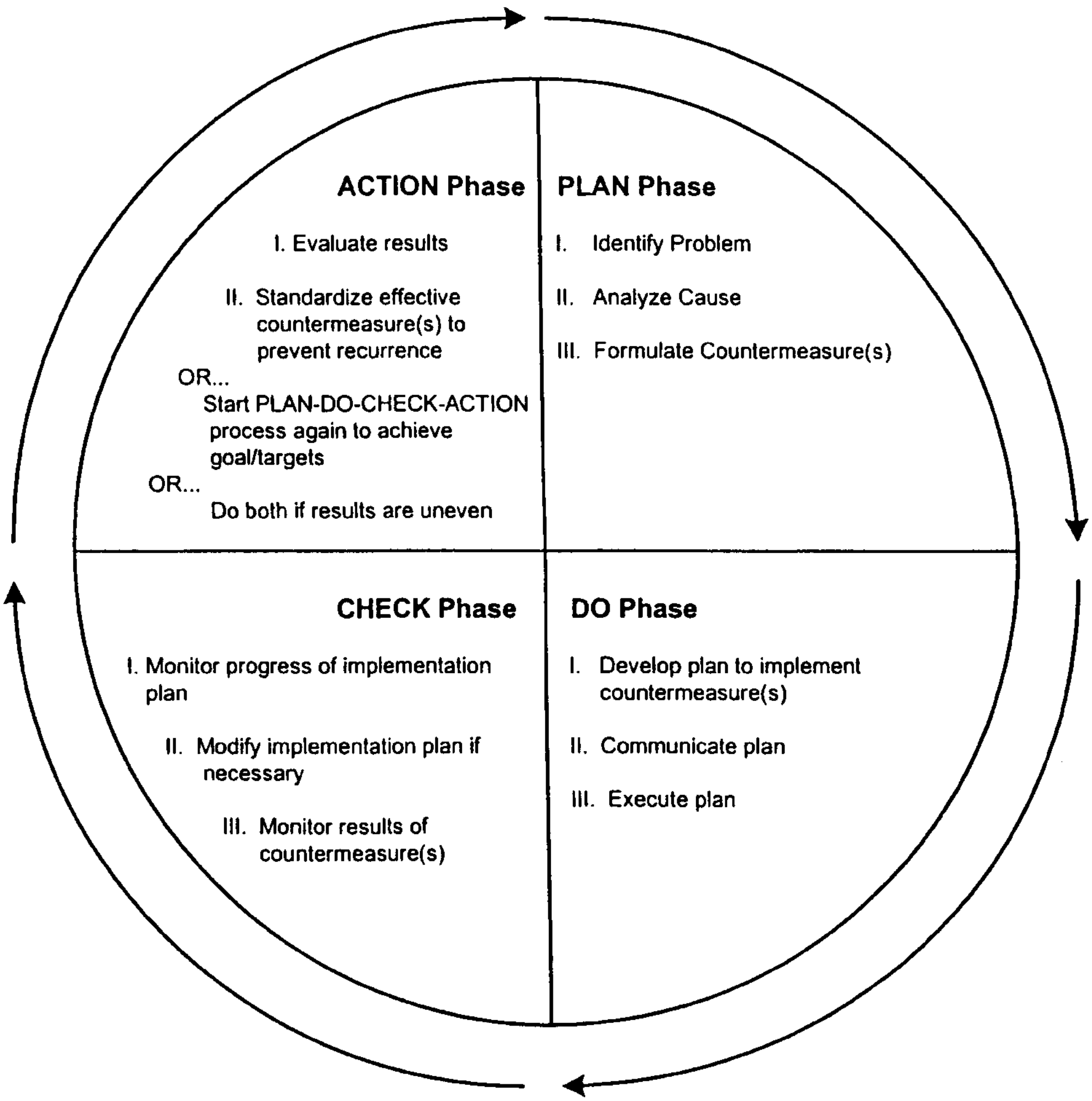

FIGURE 29.12 PDCA cycle.

receives a high priority within the manufacturing facility, since the vehicles selected were approved throughout the system and are ready to be sent to the customer.

Additional in-system checks may be performed by the personnel of production, tooling, and other departments to verify that their areas are meeting requirements. All have the same goals of defect-free quality and increased customer satisfaction.

THE OUTLOOK FOR AUTOMOTIVE QUALITY

Steady Gains. The world's automotive industry met the challenge of converting from handcraft to mass production and went on to produce tremendous improvements in product quality. Better processes, materials, equipment, and worker training yielded great gains in consistency as production lines moved faster and faster in mass production's early years. The industry also responded well to the growth of consumerism and environmental awareness with substantial improvements in product quality and safety and in the reduction of emissions and effluents both from vehicles and from the plants that produce them.

Next Steps. In the final years of the twentieth century and into the next, the industry will consolidate and reinforce these gains in product quality, reliability, and environmental acceptability. Further quality gains will come from team production methods, from the use of robotics, and from just-in-time production control and the other techniques that in Toyota are known as the “Toyota production system”. Supplier relationships, already very close in many parts of the industry, will grow closer still, with manufacturers and suppliers sharing even more of their product plans, production methods, and quality disciplines.

The growth of intelligent transportation systems, which will have intelligent vehicles traveling intelligent highways, will bring about new quality concerns and opportunities. Distance sensors, “smart” cruise control, onboard navigation systems, built-in diagnostic devices and other electronic equipment will add complexities to the measurement of quality and require new approaches to in-plant process control and quality assurance methods. Many of the suppliers of these components may be companies not now involved with automakers and unfamiliar with automobile industry quality initiatives.

The New Battleground. The primary quality battleground, however, will shift from the production plant to the retail sale. More and more surveys, studies, and focus-group comments show that automobile buyers associate quality not only with the product but also with the purchase and service experiences that accompany it—the components of customer satisfaction.

Success in the retail battleground may be the automobile industry’s greatest challenge, for it is here that the automobile manufacturer exercises the least control over any aspect of the design/production/distribution/sale process. Although the manufacturer influences this part of the process, the conversion of prospects into customers rests with independent dealers.

If the automaker is to meet the buyer’s needs, it needs to know much more about changes in buyer demographics and about the changing ways motor vehicles fit into new lifestyles. Manufacturers must consider the new and greater pressures on the buyer’s time and financial resources, changes in commuting habits, the growth of entrepreneurship, and the work-at-home phenomenon, among other factors.

Some opportunities are available to the automobile manufacturer interested in improving the sale and service experience, however. Dealer training may be the greatest of these opportunities, since manufacturers can do much to raise the level of knowledge and professionalism among dealers’ sales and service employees. Most manufacturers have programs in place for this kind of training. All are likely to be accelerated as competition drives the need for more and better customer relations.

Another area for improvement is emphasis on “lean distribution”, the field equivalent of lean production. Manufacturers will be working on ways to improve their responsiveness to vehicle orders, which would have the combined effects of pleasing customers with prompt delivery as it shrinks costly dealer inventories.

Finally, manufacturers will be able to improve the quality of the vehicle-purchase experience through customer education and communication, mainly by way of the Internet. Growing numbers of automobile buyers are gathering information about motor vehicles electronically from their homes as they begin the search. This puts customer and manufacturer into direct, two-way communication in ways never before available. New capabilities lent by Internet communications range from simple matters such as showing the automobile buyer how a certain vehicle would look in his or her choice of colors and appearance options to detailed answers to highly technical questions about performance, materials, warranty details, and other matters.

The automotive industry is being challenged to change from quality considerations based on product to those which include all aspects of the ownership experience. How we meet this challenge will test each of us about responsiveness, adaptability, and genuine customer-service attitudes.

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