SECTION 3
THE QUALITY PLANNING PROCESS*

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DEFINITION OF QUALITY PLANNING

"Quality planning," as used here, is a structured process for developing products (both goods and services) that ensures that customer needs are met by the final result. The tools and methods of quality planning are incorporated along with the technological tools for the particular product being developed and delivered. Designing a new automobile requires automotive engineering and related disciplines, developing an effective care path for juvenile diabetes will draw on the expert methods of specialized physicians, and planning a new approach for guest services at a resort will require the techniques of an experienced hotelier. All three need the process, methods, tools, and techniques of quality planning to ensure that the final designs for the automobile, diabetic care, and resort services not only fulfill the best technical requirements of the relevant disciplines but also meet the needs of the customers who will purchase and benefit from the products.

THE QUALITY PLANNING PROBLEM

The quality planning process and its associated methods, tools, and techniques have been developed because in the history of modern society, organizations have rather universally demonstrated a consistent failure to produce the goods and services that unerringly delight their customers. As a customer, everyone has been dismayed time and time again when flights are delayed, radioactive contamination spreads, medical treatment is not consistent with best practices, a child's toy fails to function, a new piece of software is not as fast or user-friendly as anticipated, government responds with glacial speed (if at all), or a home washing machine with the latest high-tech gadget delivers at higher cost clothes that are no cleaner than before. These frequent, large quality gaps are really the compound result of a number of smaller gaps illustrated in Figure 3.1.

The first component of the quality gap is the *understanding gap,* that is, lack of understanding of what the customer needs. Sometimes this gap opens up because the producer simply fails to consider who the customers are and what they need. More often the gap is there because the supplying organization has erroneous confidence in its ability to understand exactly what the customer really needs. The final perception gap in Figure 3.1 also arises from a failure to understand the customer and the customer needs. Customers do not experience a new suit of clothes or the continuity in service from a local utility simply based on the technical merits of the product. Customers react to how they *perceive* the good or service provides them with a benefit.

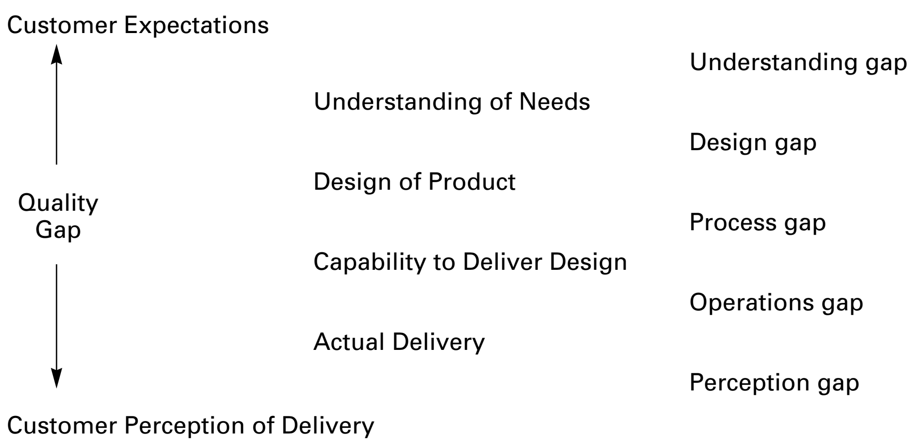

FIGURE 3.1 The quality gap and its constituent gaps. [*Inspired by A. Parasuraman, Valarie A. Zeithami, and Leonard L. Berry (1985). "A Conceptual Model for Service Quality and Its Implications for Further Research." Journal of Marketing, Fall, pp. 41–50.*]

The second constituent of the quality gap is a *design gap.* Even if there were perfect knowledge about customer needs and perceptions, many organizations would fail to create designs for their goods and services that are fully consistent with that understanding. Some of this failure arises from the fact that the people who understand customers and the disciplines they use for understanding customer needs are often systematically isolated from those who actually create the designs. In addition, designers—whether they design sophisticated equipment or delicate human services—often lack the simple tools that would enable them to combine their technical expertise with an understanding of the customer needs to create a truly superior product.

The third gap is the *process gap.* Many splendid designs fail because the process by which the physical product is created or the service is delivered is not capable of conforming to the design consistently time after time. This lack of process capability is one of the most persistent and bedeviling failures in the total quality gap.

The fourth gap is the *operations gap.* The means by which the process is operated and controlled may create additional deficiencies in the delivery of the final good or service.

- Establish the project
- Identify the customers
- Discover the customer needs
- Develop the product
- Develop the process
- Develop the controls and transfer to operations

FIGURE 3.2 Quality planning steps. (*Juran Institute, Inc., Copyright 1994. Used by permission.*)

THE QUALITY PLANNING SOLUTION

Quality planning provides the process, methods, tools, and techniques for closing each of these component gaps and thereby ensuring that the final quality gap is at a minimum. Figure 3.2 summarizes at a high level the basic steps of quality planning. The remainder of this section will provide the details and examples for each of these steps.

The first step, establish the project, provides the clear goals, direction, and infrastructure required if the constituent quality gaps are to be closed. The next step provides for systematic identification of all the customers. It is impossible to close the understanding gap if there is the least bit of uncertainty, fuzziness, or ignorance about who all the customers are.

The discovery of customer needs in the third step provides the full and complete understanding required for a successful product design to meet those needs. It also evaluates customer perceptions explicitly so that the final perception gap can be avoided.

The develop product step uses both quality planning tools and the technology of the particular industry to create a design that is effective in meeting the customer needs, thereby closing the design gap. The process gap is closed in the next step, develop process. Quality planning techniques ensure that the process is capable of delivering the product as it was designed, consistently, time after time.

Finally, the operations gap is closed by developing process controls that keep the process operating at its full capability. Successful elimination of the operations gap also depends on an effective transfer of the plans to the operating forces. A strong transfer plan, executed well, will provide operations with all the processes, techniques, materials, equipment, skills, and so on to delight customers on a continuing basis.

The remainder of this section will provide details, practical guidance, and examples for each of these steps. Many detailed examples will be included of how Ford Motor Company applied the principles of quality planning to develop its 1994 Ford Mustang.

STEP 1: ESTABLISH THE PROJECT

A quality planning project is the organized work needed to prepare an organization to deliver a new or revised product, following the steps associated with quality planning. Generally speaking, the following activities are associated with establishing a quality planning project:

- Identify which projects are required to fulfill the organization's strategy.
- Prepare a mission statement for each project.
- Establish a team to carry out the project.
- Plan the project.

Identification of Projects. Deciding which projects to undertake is usually the outgrowth of the strategic and business planning of an organization. (See Section 13, Strategic Deployment for a discussion of how specific projects are deployed from an organization's vision, strategies, and goals.) Typically, quality planning projects create new or updated products that are needed to reach specific strategic goals, to meet new or changing customer needs, to fulfill legal or customer mandates, or to take advantage of a new or emerging technology.

Upper management must take the leadership in identifying and supporting the critical quality planning projects. Acting as a quality council or similar body, management needs to fulfill the following key roles.

Setting Quality Goals. Top management identifies opportunities and needs to improve quality and sets strategic goals for the organization.

Nominating and Selecting Projects. The quality council selects those major quality planning projects critical to meeting strategic quality goals.

Selecting Teams. Once a project has been identified, the quality council appoints a team to see the project through the remaining steps of the quality planning process.

Supporting Project Team. New techniques and processes are generally required to meet quality goals. It is up to the quality council to see that each quality planning team is well prepared and equipped to carry out its mission. The quality council's support may include

- Providing education and training in quality planning tools and techniques
- Providing a trained facilitator to help the team work effectively and learn the quality planning process
- Reviewing team progress
- Approving revision of the project mission
- Identifying/helping with any problems
- Coordinating related quality planning projects
- Helping with logistics, such as a meeting site
- Providing expertise in data analysis and survey design
- Furnishing resources for unusually demanding data collection
- Communicating project results

Monitoring Progress. The quality council is generally responsible for keeping the quality planning process on track, evaluating progress, and making midcourse corrections to improve the effectiveness of the entire process. Once the quality council has reviewed the sources for potential projects, it will select one or more for immediate attention. Next, it must prepare a mission statement for the project.

Prepare Mission Statement. Once the quality council has identified the need for a project, it should prepare a mission statement that incorporates the specific goal(s) of the project. The mission statement is the written instruction for the team that describes the intent or purpose of the project. The team mission describes

- The scope of the planning project, that is, the product and markets to be addressed
- The goals of the project, that is, the results to be achieved

Writing mission statements requires a firm understanding of the driving force behind the project. The mission helps to answer the following questions:

- Why does the organization want to do the project?
- What will it accomplish once it is implemented?

A mission statement also fosters a consensus among those who either will be affected by the project or will contribute the time and resources necessary to plan and implement the project goal.

Examples

- The team mission is to deliver to market a new low-energy, fluorocarbon-free refrigerator.
- The team will create accurate control and minimum cost for the inventory of all stores.

While these mission statements describe what will be done, they are still incomplete. They lack the clarity and specificity that is required of a complete quality planning mission statement that incorporates the goal(s) of a project. Well-written and effective mission statements define the scope of the project by including one or more of the following.

Inherent performance: How the final product will perform on one or more dimensions, e.g., 24-hour response time.

Comparative performance: How the final product will perform vis-à-vis the competition, e.g., the fastest response time in the metropolitan area.

Customer reaction: How customers will rate the product compared with others available, e.g., one company is rated as having a better on-time delivery service compared with its closest rival.

Market: Who are or will be the customers or target audience for this product, and what share of the market or market niche will it capture, e.g., to become the "preferred" source by all business travelers within the continental United States.

Performance deficiencies: How will the product perform with respect to product failure, e.g., failure rate of less than 200 for every million hours of use.

Avoidance of unnecessary constraints: Avoid overspecifying the product for the team, e.g., if the product is intended for airline carryon, specifying the precise dimensions in the mission may be too restrictive. There may be several ways to meet the carryon market.

Basis for Establishing Quality Goals. In addition to the scope of the project, a mission statement also must include the goal(s) of the project. An important consideration in establishing quality goals is the choice of the basis for which the goal(s) are set.

Technology as a Basis. In many organizations, it has been the tradition to establish the quality goals on a technological basis. Most of the goals are published in specifications and procedures that define the quality targets for the supervisory and nonsupervisory levels.

The Market as a Basis. Quality goals that affect product salability should be based primarily on meeting or exceeding market quality. Because the market and the competition undoubtedly will be changing while the quality planning project is under way, goals should be set so as to meet or beat the competition estimated to be prevailing when the project is completed. Some internal suppliers are internal monopolies. Common examples include payroll preparation, facilities maintenance, cafeteria service, and internal transportation. However, most internal monopolies have potential competitors. There are outside suppliers who offer to sell the same service. Thus the performance of the internal supplier can be compared with the proposals offered by an outside supplier.

Benchmarking as a Basis. "Benchmarking" is a recent label for the concept of setting goals based on knowing what has been achieved by others. (See Section 12.) A common goal is the requirement that the reliability of a new product be at least equal to that of the product it replaces and at least equal to that of the most reliable competing product. Implicit in the use of benchmarking is the concept that the resulting goals are attainable because they have already been attained by others.

History as a Basis. A fourth and widely used basis for setting quality goals has been historical performance; i.e., goals are based on past performance. Sometimes this is tightened up to stimulate improvement. For some products and processes, the historical basis is an aid to needed stability. In other cases, notably those involving chronically high costs of poor quality, the historical basis helps to perpetuate a chronically wasteful performance. During the goal-setting process, the management team should be on the alert for such misuse of the historical basis.

Quality Goals Are a Moving Target. It is widely recognized that quality goals must keep shifting to respond to the changes that keep coming over the horizon: new technology, new competition, threats, and opportunities. While organizations that have adopted quality management methods practice this concept, they may not do as well on providing the means to evaluate the impact of those changes and revise the goals accordingly.

Project Goals. Specific goals of the project, i.e., what the project team is to accomplish, are part of an effective mission statement. In getting the job done, the team must mentally start at the finish. The more focused it is on what the end result will look like, the easier it will be to achieve a successful conclusion.

Measurement of the Goal. In addition to stating what will be done and by when, a project goal must show how the team will measure whether or not it has achieved its stated goals. It is important to spend some time defining how success is measured. Listed below are the four things that can be measured:

1. Quality
2. Quantity
3. Cost
4. Time

An effective quality planning project goal must have five characteristics for it to provide a team with enough information to guide the planning process. The goal must be

- Specific
- Measurable
- Agreed to by those affected
- Realistic—It can be a stretch, but it must be plausible.
- Time specific—when it will be done

An example of a poorly written goal might look something like this: "To design a new car that is best in class." Contrast this with the following example: "To design, and put into production within 3 years, a new, midsized car that is best in class and priced, for the public, at under $20,000 (at time of introduction). The design also should allow the company to sell the car and still have an average return of between 4 and 6 percent."

The second example is much more detailed, measurable, and time-specific compared with the first. The target or end result is clearly stated and provides enough direction for the team to plan the product features and processes to achieve the goal.

The Ford Mustang—Mission and Goals. Before moving ahead with any product development, Ford agreed to a clear mission for the Mustang. The short version was "The Car The Star." Whenever a large group of people from various functional organizations is brought together to work on a project, there is a natural tendency to bring a lot of their "home office priorities and objectives" to the team. Unattended, these home office priorities can diffuse the team's focus and create a significant amount of conflict within the team.

To address this issue, the team chose the statement "The Car is the Star" to align the efforts of all team members and to focus them on a single objective. This statement was a simple and effective way to galvanize the team around the fact that there was one common purpose and a single superordinate objective.

Specifically, this meant that all team members could adjudicate their daily decisions and actions consistent with the overall team objective of making the car a reality and success. Program goals were established for 18 separate parameters. These "18 panel charts" enabled the project to focus on very specific success factors. (See Figure 3.3.)

	Topic	Description
Panel 1:	Quality	Things gone wrong/1000, things gone right/1000, repairs/1000 and customer satisfaction @ 3 months in service, plus things gone wrong/1000 @ 4 years in service.
Panel 2:	Timing	Summary of the major milestones from the total program workplan.
Panel 3:	Vehicle hardpoints	Summary of the architectural hardpoints such as wheelbase, tread, length, height, width, interior room, leg room, etc.
Panel 4:	Vehicle dynamics	Subjective targets for performance feel, ride, handling, noise/vibration/harshness, brake performance, seat performance, etc.
Panel 5:	Weight	Curb weight and emission test weight for all models.
Panel 6:	Fuel economy	Metro-highway fuel consumption is declared for all models. Avoidance of gas guzzler is also declared.
Panel 7:	Performance	0–60 mph elapsed time is declared for all models.
Panel 8:	Complexity	Number of discrete customer decisions and buildable combinations is declared.
Panel 9:	Serviceability	Projection for the number of total service hours through 50,000 miles is declared.
Panel 10:	Damageability	Projected repair cost for a typical collision is declared.
Panel 11:	Safety emissions	Compliance with all applicable Federal Motor Vehicle Safety Standards and Federal Clean Air Standards is declared.
Panel 12:	Variable cost	Variable cost versus prior model is declared.
Panel 13:	Program investment	Total investment for tooling, facilities, launch, and engineering is declared.
Panel 14:	Pricing	Wholesale delivery price is declared for all models.
Panel 15:	Volumes	Five year projection for trend volume is declared.
Panel 16:	Profitability	Program profitability is declared in terms of fully accounted profits.
Panel 17:	Features	All product standard features and option by model are declared.
Panel 18:	Export	Export markets and volumes are declared.

FIGURE 3.3 Ford Mustang 18 panel chart goals.

New Product Policies. Companies need to have very clear policy guidance with respect to quality and product development. Most of these should relate to all new products, but specific policies may relate to individual products, product lines, or groups. Four of the most critical policies are as follows.

Deficiencies in New and Carryover Designs. Many organizations have established the clear policy that no new product or component of a product will have a higher rate of deficiencies than the old product or component that it is replacing. In addition, they often require that any carryover design must have a certain level of performance; otherwise, it must be replaced with a more reliable design. The minimum carryover reliability may be set by one or more of the following criteria: (1) competitor or benchmark reliability, (2) customer requirements, or (3) a stretch goal beyond benchmark or customer requirements.

Intended versus Unintended Use. Should stepladders be designed so that the user can stand on the top step without damage, even though the step is clearly labeled "Do Not Step Here?" Should a hospital design its emergency room to handle volumes of routine, nonemergency patients who show up at its doors? These are policy questions that need to be settled before the project begins. The answers can have a significant impact on the final product, and the answers need to be developed with reference to the organization's strategy and the environment within which its products are used.

Requirement of Formal Quality Planning Process. A structured, formal process is required to ensure that the product planners identify their customers and design products and processes that will meet those customer needs with minimum deficiencies. Structured formality is sometimes eschewed as a barrier to creativity. Nothing could be more misguided. Formal quality planning identifies the points at which creativity is demanded and then encourages, supports, and enables that creativity. Formal planning also ensures that the creativity is focused on the customers and that creative designs ultimately are delivered to the customer free of the destructive influences of deficiencies.

Custody of Designs and Change Control. Specific provision must be made to ensure that approved designs are documented and accessible. Any changes to designs must be validated, receive appropriate approvals, be documented, and be unerringly incorporated into the product or process. Specific individuals must have the assigned authority, responsibility, and resources to maintain the final designs and administer change control.

Ford Policies with Respect to the Mustang. Ford had three specific policies with respect to carryover and new designs. New designs were required to be more reliable than the old. They also were required to provide demonstrated cost-benefit contributions to the final product. Finally, major features were expected to exceed the performance of the chief competitor—Camaro/Firebird.

Because Mustang needed to maintain its reputation as a reliable performance car, a more stringent testing policy was established. In addition to the safety, economy, reliability, durability, and other tests that all Ford cars must pass, the Mustang was required to pass tests such as 500 drag starts without a failure and repeated hard braking without fading.

Establish Team. The cross-functional approach to quality planning is effective for several reasons:

Team involvement promotes sharing of ideas, experiences, and a sense of commitment to being a part of and helping "our" organization achieve its goal.

The diversity of team members brings a more complete working knowledge of the product and processes to be planned. Planning a product requires a thorough understanding of how things get done in many parts of the organization.

Representation from various departments or functions promotes the acceptance and implementation of the new plan throughout the organization. Products or processes designed with the active participation of the affected areas tend to be technically superior and accepted more readily by those who must implement them.

Guidelines for Team Selection. When selecting a team, the quality council identifies those parts of the organization which have a stake in the outcome. There are several places to look:

- Those who will be most affected by the result of the project
- Departments or functions responsible for various steps in the process
- Those with special knowledge, information, or skill in the design of the project
- Areas that can be helpful in implementing the plan

The Mustang Team. Ford established a dedicated team of individuals from all key parts of the company, including

Stakeholder organizations	*Role*
Vehicle Engineering	Team leader
Product and Business Planning	Prepare the product assumptions and business case.
Body and Chassis Engineering	Define the product upgrades to satisfy the customer for comfort, convenience, and safety and to meet the forecasted federal motor vehicle safety standards.
Power Train Engineering	Define the power train upgrades to satisfy the customer wants for power and drivability and meet the clean air and gas guzzler requirements.
Vehicle Design	Provide excitement with a highly styled design.
Manufacturing and Assembly	Ensure that there is a feasible, high-quality product.
Sales and Marketing	Provide the "voice of the customer" and ensure that the product hits the target market.
Purchasing	Bring the suppliers to the party.
Finance	Help the team develop a financially attractive business package.

Besides their professional expertise for the job, many of the team members also were Mustang enthusiasts who brought an understanding and passion for the customer needs that would be hard to duplicate.

Because an automobile is a highly complex consumer product, the work was divided into five chunk teams: body exterior and structure, body interior and electrical, power train, chassis, and vehicle. Each chunk team had members from all the major stakeholders and was able to manage its portion of the program with autonomy within the overall design and 18 panel chart parameters.

The overall coordination and direction of the work among the chunk teams was managed with a weekly "major matters" meeting among the chunk team leaders and the program manager. These meetings focused on the major program metrics incorporated in the 18 panel charts.

STEP 2: IDENTIFY THE CUSTOMERS

This step may seem unnecessary; of course, the planners and designers know who their customers are: the driver of the automobile, the depositor in the bank account, the patient who takes the medication. But these are not the only customers—not even necessarily the most important customers. Customers comprise an entire cast of characters that needs to be understood fully.

Generally, there are two primary groups of customers: the *external customers*—those outside the producing organization; and the *internal customers*—those inside the producing organization.

Types of External Customers. The term "customer" is often used loosely; it can refer to an entire organization, a unit of a larger organization, or a person. There are many types of customers—some obvious, others hidden. Below is a listing of the major categories to help guide complete customer identification.

The purchaser	Someone who buys the product for himself or herself or for someone else, e.g., anyone who purchases food for his or her family.
The end user/ultimate customer	Someone who finally benefits from the product, e.g., the patient who goes to health care facility for diagnostic testing.
Merchants	People who purchase products for resale, wholesalers, distributors, travel agents and brokers, and anyone who handles the product, such as a supermarket employee who places the product on the shelf.
Processors	Organizations and people who use the product or output as an input for producing their own product, e.g., a refinery that receives crude oil and processes it into different products for a variety of customers.
Suppliers	Those who provide input to the process, e.g., the manufacturer of the spark plugs for an automobile or the law firm that provides advice on the company's environmental law matters. Suppliers are also customers. They have information needs with respect to product specification, feedback on deficiencies, predictability of orders, and so on.
Original equipment manufacturers (OEMs)	Purchasers of a product to incorporate into their own, e.g., a computer manufacturer using another producer's disk drives for its computers.
Potential customers	Those not currently using the product but capable of becoming customers; e.g., a business traveler renting a car may purchase a similar automobile when the time comes to buy one for personal use.
Hidden customers	An assortment of different customers who are easily overlooked because they may not come to mind readily. They can exert great influence over the product design: regulators, critics, opinion leaders, testing services, payers, the media, the public at large, those directly or potentially threatened by the product, corporate policymakers, labor unions, professional associations.

Internal Customers. Everyone inside an organization plays three roles: supplier, processor, and customer. Each individual receives something from someone, does something with it, and passes it to a third individual. Effectiveness in meeting the needs of these internal customers can have a major impact on serving the external customers. Identifying the internal customers will require some analysis because many of these relationships tend to be informal, resulting in a hazy perception of who the customers are and how they will be affected. For example, if a company decides to introduce just-in-time manufacturing to one of its plants, this will have significant effect on purchasing, shipping, sales, operations, and so on.

Most organizations try to set up a mechanism that will allow seemingly competing functions to negotiate and resolve differences based on the higher goal of satisfying customer needs. This might include conducting weekly meetings of department heads or publishing procedure manuals. However, these mechanisms often do not work because the needs of internal customers are not fully understood, and communication among the functions breaks down. This is why a major goal in the quality planning process is to identify who the internal customers are, discover their needs, and plan how those needs will be satisfied. This is also another reason to have a multifunctional team involved in the planning; these are people who are likely to recognize the vested interests of internal customers.

Identifying Customers. In addition to the general guidance just laid out, it is most often helpful to draw a relatively high-level flow diagram of the processes related to the product being planned. Careful analysis of this flow diagram often will provide new insight, identifying customers that might have been missed and refining understanding of how the customers interact with the process. Figure 3.4 is an example of such a diagram. A review of this diagram reveals that the role of "customer" is really two different roles—placing the order and using the product. These may or may not be played by the same individuals, but they are two distinct roles, and each needs to be understood in terms of its needs.

Customers for Ford Mustang. The most critical customer for Ford Mustang was the "ultimate customer," namely, the person who would purchase the vehicle. The prime demographic target group was the Mustang GT buyer. (The GT model is the image setter and the model that must appeal to the enthusiast if the car line is to be successful.)

Other vital few external customers included

Dealers

Suppliers

Government

- Environmental Protection Agency (EPA)
- The National Highway and Traffic Safety Administration (NHTSA)
- The Federal Trade Commission (FTC)

Media (refers to both the internal and external sources)

- Internal media

  Ford Communication Network (FCN)

  Employee publications

- External media

  Enthusiast magazines such as *Motor Trend Magazine, Car and Driver, Road & Track, Automobile Magazine, AutoWeek,* etc.

  Trade magazines such as *Ward's AutoWorld, Automotive News, Automotive Industries, Automotive Engineering.*

  National television programs such as "Motorweek," "MotorTrend."

  Local and regional television programs

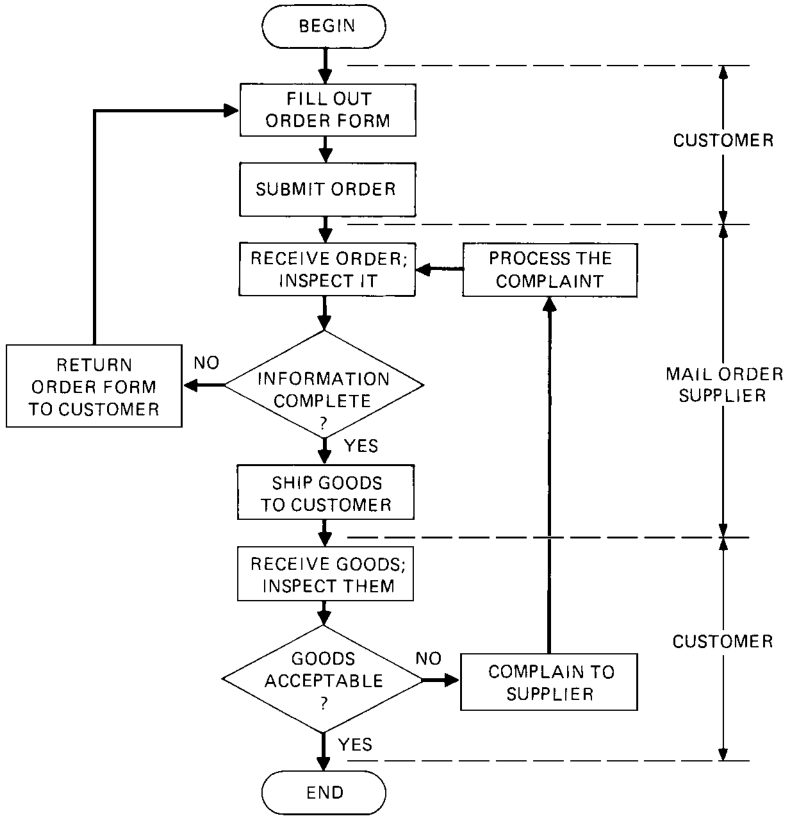

FIGURE 3.4 The flow diagram and customers. [*From Juran, J. M. (1988), Quality Control Handbook, 4th ed. McGraw-Hill, New York, p. 6.6.*]

Local and regional radio programs

Local and regional newspaper coverage

Internal Customers

Corporate management

Product Engineering Office

Assembly plant

Ford Customer Service Division

Marketing

Sales

Purchasing

Public affairs

Internal media

- Ford Communication Network (FCN)
- Employee publications

STEP 3: DISCOVER CUSTOMER NEEDS

The third step of quality planning is to discover the needs of both internal and external customers for the product. Some of the key activities required for effective discovery of customer needs include

- Plan to collect customers' needs.
- Collect a list of customers' needs in their language.
- Analyze and prioritize customers' needs.
- Translate their needs into "our" language.
- Establish units of measurement and sensors.

Our own experience tells us that the needs of human beings are both varied and complex. This can be particularly challenging to a planning team because the actions of customers are not always consistent with what they *say* they want. The challenge for quality planning is to identify the most important needs from the full array of those needs expressed or assumed by the customer. Only then can the product delight the customers.

When designing a product, there are actually two related but distinct aspects of what is being developed: the *technology* elements of what the product's features *will actually do or how it will function* and the *human* elements of the *benefits customers will receive from using the product.* The two must be considered together.

Discovering customer needs is a complex task. Experience shows that customers usually do not state, in simple terms, exactly what they want; often they do not even mention some of their most basic needs. Accuracy of bank statements, competence of a physician, reliability of a computer, and grammatical correctness of a publication may be assumed and never stated without probing.

One of the ways customers express their needs is in terms of problems they experience and their expectation that a product will solve their problems. For example, a customer may state, "I cannot always answer my telephone personally, but I do not want callers to be either inconvenienced or disgusted with nonresponsive answering systems," or, " My mother's personal dignity and love of people are very important to me. I want to find an extended care facility that treats her like a person, not a patient." Even when the need is not *expressed* in such terms, the art and science of discovering needs are to understand exactly the benefit that the customer expects.

When a product's features meet a customer's need, it gives the customer a feeling of satisfaction. If it fails to deliver the promised feature defect-free, the customer feels dissatisfaction. Even if a product functions the way it has been designed, a competing product, by virtue of superior service or performance, may provide customers with greater satisfaction.

Stated Needs and Real Needs. Customers commonly state their needs as seen from their viewpoint and in their language. Customers may state their needs in terms of the goods or services they wish to buy. However, their real needs are the benefits they believe they will receive. To illustrate:

Customer wishes to buy…	*Benefit customer needs might include…*
Fresh pasta	Nourishment and taste
Newest personal computer	Write reports quickly and easily Find information on the Web Help children learn math
Health insurance	Security against financial disaster Access to high quality health care Choice in health care providers
Airline ticket	Transportation, Comfort, Safety, and Convenience

Failure to grasp the difference between stated needs and real needs can undermine a quality planning project. Understanding the real needs does not mean that the planners can dismiss the customers' statements and substitute their own superior technical understanding as being the customers' real needs. Understanding the real needs means asking and answering such questions as

Why is the customer buying this product?

What service does he or she expect from it?

How will the customer benefit from it?

How does the customer use it?

What has created customer complaints in the past?

Why have customers selected competitor products over ours?

Perceived Needs. Customers understandably state their needs based on their *perceptions.* These may differ entirely from the supplier's perceptions of what constitutes product quality. Planners can mislead themselves by considering whether the customers' perceptions are wrong or right rather than focusing on how these perceptions influence their buying habits. While such differences between customers and suppliers are potential troublemakers, they also can be an opportunity. Superior understanding of customer perceptions can lead to competitive advantage.

Cultural Needs. The needs of customers, especially internal customers, go beyond products and processes. They include primary needs for job security, self-respect, respect of others, continuity of habit patterns, and still other elements of what we broadly call the "cultural values"; these are seldom stated openly. Any proposed change becomes a threat to these important values and hence will be resisted until the nature of the threat is understood.

Needs Traceable to Unintended Use. Many quality failures arise because a customer uses the product in a manner different from that intended by the supplier. This practice takes many forms. Patients visit emergency rooms for nonemergency care. Untrained workers are assigned to processes requiring trained workers. Equipment does nor receive specified preventive maintenance.

Factors such as safety may add to the cost, yet they may well result in a reduced overall cost by helping to avoid the higher cost arising from misuse of the product. What is essential is to learn the following:

What will be the actual use (and misuse)?

What are the associated costs?

What are the consequences of adhering only to intended use?

Human Safety. Technology places dangerous products into the hands of amateurs who do not always possess the requisite skills to handle them without accidents. It also creates dangerous byproducts that threaten human health, safety, and the environment. The extent of all this is so great that much of the effort of product and process planning must be directed at reducing these risks to an acceptable level. Numerous laws, criminal and civil, mandate such efforts.

"User Friendly." The amateur status of many users has given rise to the term "user friendly" to describe that product feature that enables amateurs to make ready use of technological products. For example, the language of published information should be

Simple

Unambiguous

Readily understood (Notorious offenders have included legal documents, owners' operating manuals, administrative forms, etc. Widely used forms such as governmental tax returns should be field tested on a sample of the very people who will later be faced with filling out such forms.)

Broadly compatible (For example, new releases of software should be "upward compatible with earlier releases.")

Promptness of Service. Services should be prompt. In our culture, a major element of competition is promptness of service. Interlocking schedules (as in mail delivery or airline travel) are another source of a growing demand for promptness. Still another example is the growing use of just-in-time manufacturing, which requires dependable deliveries of materials to minimize inventories. All such examples demonstrate the need to include the element of promptness in planning to meet customer needs.

Customer Needs Related to Deficiencies. In the event of product failure, a new set of customer needs emerges—how to get service restored, and how to get compensated for the associated losses and inconvenience. Clearly, the ideal solution to all this is to plan quality so that there will be no failures. At this point, we will look at what customers need when failures do occur.

Warranties. The laws governing sales imply that there are certain warranties given by the supplier. However, in our complex society, it has become necessary to provide specific, written contracts to define just what is covered by the warranty and for how long a time. In addition, it should be clear who has what responsibilities.

Effect of Complaint Handling on Sales. While complaints deal primarily with product dissatisfaction, there is a side effect on salability. Research in this area has pointed out the following: Of the customers who were dissatisfied with products, nearly 70 percent did not complain. The proportions of these who did complain varied depending on the type of product involved. The reasons for not complaining were principally (1) the effort to complain was not worth it, (2) the belief that complaining would do no good, and (3) lack of knowledge about how to complain. More than 40 percent of the complaining customers were unhappy with the responsive action taken by the suppliers. Again, percentages varied depending on the type of product.

Future salability is strongly influenced by the action taken on complaints. This strong influence also extends to brand loyalty. Even customers of popular brands of "large ticket" items, such as durable goods, financial services, and automobile services, will reduce their intent to buy when they perceive that their complaints are not addressed.

This same research concluded that an organized approach to complaint handling provides a high return on investment. The elements of such an organized approach may include

- A response center staffed to provide 24-hour access by consumers and/or a toll-free telephone number
- Special training for the employees who answer the telephones
- Active solicitation of complaints to minimize loss of customers in the future

Keeping Customers Informed. Customers are quite sensitive to being victimized by secret actions of a supplier, as the phrase "Let the buyer beware!" implies. When such secrets are later discovered and publicized, the damage to the supplier's quality image can be considerable. In a great many cases, the products are fit for use despite some nonconformances. In other cases, the matter may be debatable. In still other cases, the act of shipment is at the least unethical and at the worst illegal.

Customers also have a need to be kept informed in many cases involving product failures. There are many situations in which an interruption in service will force customers to wait for an indefinite period until service is restored. Obvious examples are power outages and delays in public transportation. In all such cases, the customers become restive. They are unable to solve the problem—they must leave that to the supplier. Yet they want to be kept informed as to the nature of the problem and especially as to the likely time of solution. Many suppliers are derelict in keeping customers informed and thereby suffer a decline in their quality image. In contrast, some airlines go to great pains to keep their customers informed of the reasons for a delay and of the progress being made in providing a remedy.

Plan to Collect Customers' Needs. Customer needs keep changing. There is no such thing as a final list of customer needs. While it can be frustrating, planning teams must realize that even while they are in the middle of the planning process, forces such as technology, competition, social change, and so on, can create new customer needs or may change the priority given to existing needs. It becomes extremely important to check with customers frequently and monitor the marketplace.

Some of the most common ways to collect customer needs include

- Customer surveys, focus groups, and market research programs and studies
- Routine communications, such as sales and service calls and reports, management reviews, house publications
- Tracking customer complaints, incident reports, letters, and telephone contacts
- Simulated-use experiments and planning processes that involve the customer
- Employees with special knowledge of the customer: sales, service, clerical, secretarial, and supervisory who come into contact with customers
- Customer meetings
- User conferences for the end user
- Information on competitors' products
- Personal visits to customer locations; observe and discuss

  How product is used
  Unintended uses
  Service failures by others
  What current or new features will relieve onerous tasks
  Changes in habits and culture
  Changes in sales
  Existence of or changes in premium prices
  Sale of spare parts or after-sale service
  Purchase of options

- Government or independent laboratory data
- Changes in federal, state, and local regulations that will identify current need or new opportunity
- Competitive analysis and field intelligence comparing products with those of competitors
- Personal experience dealing with the customer and the product (However, it is important to be cautious about giving personal experience too much weight without direct verification by customers. The analysts must remember that looking at customer needs and requirements from a personal viewpoint can be a trap.)

Often customers do not express their needs in terms of the benefits they wish to receive from purchasing and using the product.

Discovering Mustang Customer Needs. In designing the Mustang, Ford relied heavily on the following sources for customer needs:

- Quantitative market research
- Qualitative market research
- Inspection studies
- Observational research
- Dealer input
- Customer surveys
- Direct interaction with customers
- Media feedback
- Product evaluation reports—internal and external
- Competitive evaluations

Collect List of Customers' Needs in Their Language. For a list of customers' needs to have significant meaning in planning a new product, they must be stated in terms of benefits sought. Another way of saying this is to capture needs in the customer's voice. By focusing on the benefits sought by the customer rather than on the means of delivering the benefit, designers will gain a better understanding of what the customer needs and how the customer will be using the product. Stating needs in terms of the benefits sought also can reveal opportunities for improved quality that often cannot be seen when concentrating on the product features alone.

Analyze and Prioritize Customer Needs. The information actually collected from customers is often too broad, too vague, and too voluminous to be used directly in designing a product. Both specificity and priority are needed to ensure that the design really meets the needs and that time is spent on designing for those needs which are truly the most important. The following activities help provide this precision and focus:

- Organizing, consolidating, and prioritizing the list of needs for both internal and external customers
- Determining the importance of each need for both internal and external customers
- Breaking down each need into precise terms so that a specific design response can be identified
- Translating these needs into the supplying organization's language
- Establishing specific measurements and measurement methods for each need

One of the best planning tools to analyze and organize customers' needs is the "quality planning spreadsheet."

Quality Planning Spreadsheets. Quality planning generates a large amount of information that is both useful and necessary, but without a systematic way to approach the organization and analysis of this information, the planning team may be overwhelmed by the volume and miss the message it contains.

Although planners have developed various approaches for organizing all this information, the most convenient and basic planning tool is the *quality planning spreadsheet.* The spreadsheet is a highly versatile tool that can be adapted to a number of situations. The quality planning process makes use of several kinds of spreadsheets, such as

- Customer needs spreadsheet
- Needs analysis spreadsheet

- Product design spreadsheet
- Process design spreadsheet
- Process control spreadsheet

Besides recording information, these tools are particularly useful in analyzing relationships among the data that have been collected and in facilitating the stepwise conversion of customer needs into product features and then product features into process characteristics and plans. This conversion is illustrated in Figure 3.5. Analysis of customers and their needs provides the basis for designing the product. The summary of that design feeds the process design, which feeds the control spreadsheet.

For most planning projects, simple matrix spreadsheets will suffice. For other projects, more complex quality functional deployment spreadsheets are helpful in computing design trade-offs. All these spreadsheets are designed to allow the team to record and compare the relationships among many variables at the same time. We will illustrate some of these spreadsheets at the appropriate point in the planning process. Figure 3.6 illustrates the generic layout of any one of these spreadsheets. In general, the row headings are the "what's" of the analysis—the customers to be satisfied, the needs to be met, and so on. The columns are the "how's"—the needs that, when met, will satisfy the customer, the product features that will meet the needs, and so on. The bottom row of the spreadsheet generally contains specific measurable goals for the "how" at the top. The body of the spreadsheet expresses with symbols or numerics the impact of the "how" on the "what"—e.g., none, moderate, strong, very strong. Other columns can be added to give specific measures of the importance of the respective rows, benchmarks, and so on.

Customer Needs Spreadsheet. Figure 3.7 provides a simple example of a customer needs spreadsheet. The left column lists, in priority order, all the external and internal customers. The column headings are the various needs that have been discovered. By either checking or entering a designation for importance, it is possible to create a simple but comprehensive picture of the importance of meeting each need. All product development must operate within a budget. Prioritizing the customers and their needs ensures that the budget is focused on what is most important.

Precise Customer Needs. Once the needs that must be met have been prioritized, they must be described in sufficiently precise terms to design a product based on them. A customer needs spreadsheet helps assemble this analysis. At this point, customer needs are probably a mixture of relatively broad expectations such as "ease of use" and more specific requests such as "access on Saturday." Figure 3.8 illustrates how broad needs (called "primary") are broken into succeeding levels of specificity ("secondary," "tertiary," etc.) Note that primary and secondary do not mean more and less important, they mean, respectively, less specific and more specific. Each need must be broken down to the level at which it can (1) be measured and (2) serve as an unambiguous guide for product design. In some cases two levels of detail may suffice, in others four or five may be required. Figure 3.8 illustrates how this might be done for the primary need "convenience" associated with a group medical practice.

Mustang Customer Needs. In addition to basic transportation, the following needs surfaced as most important for Mustang customers:

Safety
Performance
Image
Comfort

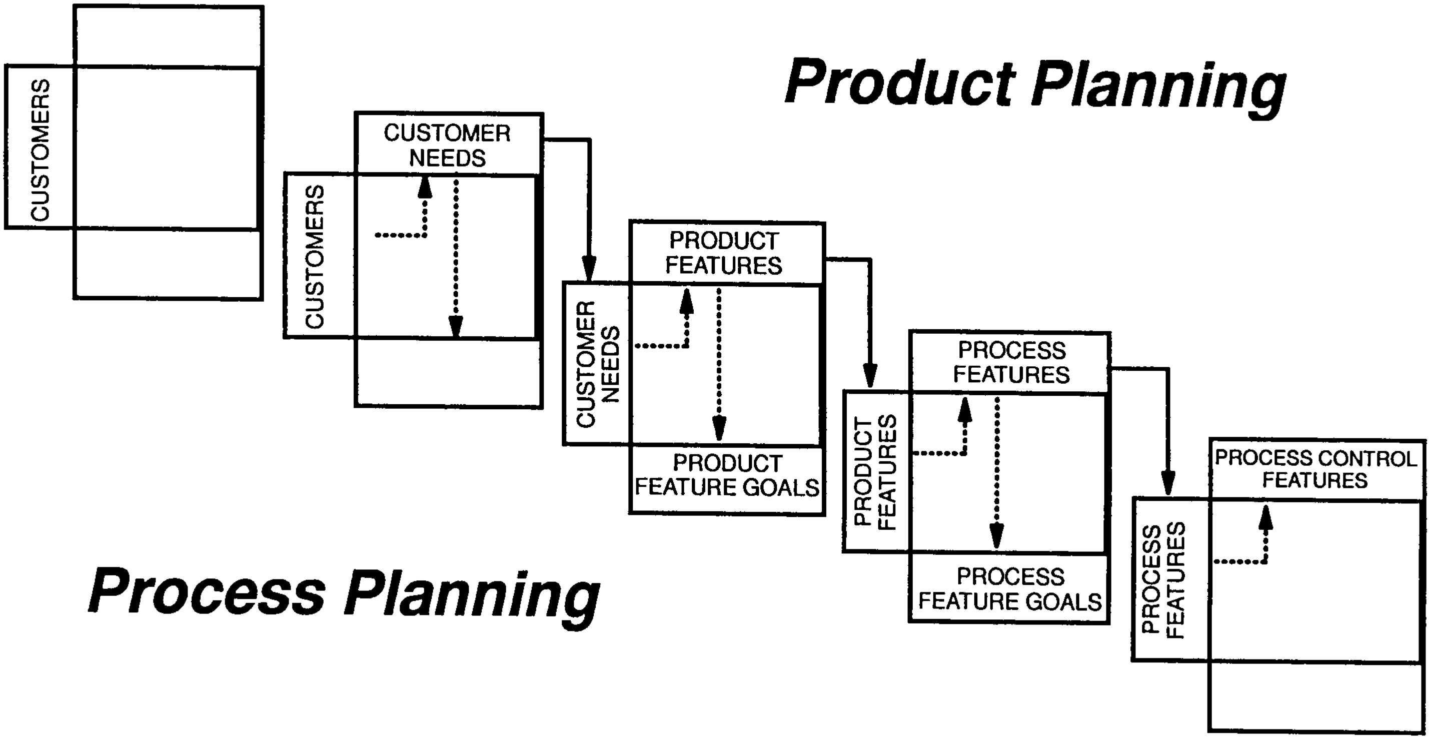

FIGURE 3.5 Spreadsheets in quality planning. *(Juran Institute, Inc. Copyright 1994. Used by permission.)*

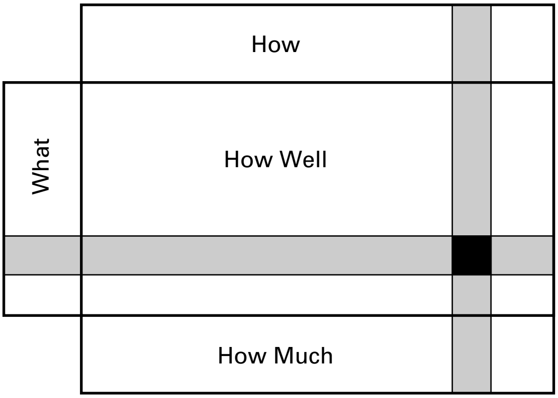

FIGURE 3.6 Generic planning spreadsheet. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Customers	Customer Needs							
	Attractive	Informative/well-written articles	Catchy cover lines	Stable circulation	It sells	Enough time	Material complete	No last minute changes
Readers	●	●	●					
Advertisers	●	○	●	●	●			
Printers						●	●	●
Typesetters						●	●	●
Color separators						●	●	●
Newsstand	●	○	●	●	●			

Legend
● Very Strong
○ Strong
△ Weak

FIGURE 3.7 Customer needs spreadsheet for a magazine. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Primary need	Secondary need	Tertiary need
Convenience	Hours of operation	Open between 5:00 and 9:00 p.m. Saturday hours
	Transportation access	Within three blocks of bus stop Ample parking
	Short wait	Urgent appointment within 24 hours Routine appointment within 14 days Waiting time at appointment less than 15 minutes
	Complementary available services	Pharmacy on site Lab on site

FIGURE 3.8 Needs analysis spreadsheet for a medical office. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Convenience

Entertainment

Reliability/dependability

Durability

Low cost of ownership

Ergonomics

Fuel economy

Handling—in all types of weather

Ride quality—regardless of road surface

Translate Their Needs into "Our" Language. The precise customer needs that have been identified may be stated in any of several languages, including

The customer's language

The supplier's ("our") language

A common language

An old aphorism claims that the British and Americans are separated by a common language. The appearance of a common language or dialect can be an invitation to trouble because both parties believe that they understand each other and expect to be understood. Failure to communicate because of the unrecognized differences can build additional misunderstanding that only compounds the difficulty. It is imperative, therefore, for planners to take extraordinary steps to ensure that they properly understand customer needs by systematically translating them. The need to translate applies to both internal and external customers. Various company functions employ local dialects that are often not understood by other functions.

Vague terminology constitutes one special case for translation that can arise even (and often especially) between customers and suppliers that believe they are speaking the same dialect. Identical words have multiple meanings. Descriptive words do not describe with technological precision.

Aids to Translation. Numerous aids are available to clear up vagueness and create a bridge across languages and dialects. The most usual are listed following:

A *glossary* is a list of terms and their definitions. It is a published agreement on the precise meanings of key terms. The publication may be embellished by other forms of communication, such as sketches, photographs, and videotapes.

Samples can take many forms, such as physical goods (e.g., textile swatches, color chips, audio cassettes) or services (e.g., video recordings to demonstrate "samples" of good service—courtesy, thoughtfulness, etc.) They serve as specifications for product features. They make use of human senses beyond those associated with word images.

A *special organization* to translate communications with external customers may be required because of the high volume of translation. A common example is the order-editing department, which receives orders from clients. Some elements of these orders are in client language. Order editing translates these elements into supplier language, e.g., product code numbers, supplier acronyms, and so on.

Standardization is used by many mature industries for the mutual benefit of customers and suppliers. This standardization extends to language, products, processes, and so on. All organizations make use of short designations for their products, such as code numbers, acronyms, words, phrases, and so on. Such standardized nomenclature makes it easy to communicate with internal customers.

Measurement is the most effective remedy for vagueness and multiple dialects—"Say it in numbers." This is the first, but not the last, point in the planning process where measurement is critical. Quality planning also requires measurement of product features, process features, process capability, control subjects, and so on.

Establish Units of Measurement and Sensors. Sound quality planning requires precise communication between customers and suppliers. Some of the essential information can be conveyed adequately by words. However, an increasingly complex and specialized society demands higher precision for communicating quality-related information. The higher precision is best attained when we say it in numbers.

Quantification requires a system of measurement. Such a system consists of

A *unit of measurement,* which is a defined amount of some quality feature, permits evaluation of that feature in numbers, e.g., hours of time to provide service, kilowatts of electric power, or concentration of a medication.

A *sensor,* which is a method or instrument of measurement, carries out the evaluation and states the findings in numbers in terms of the unit of measure, e.g., a clock for telling time, a thermometer for measuring temperature, or an x-ray to measure bone density.

By measuring customer needs, one has established an objective criterion for whether or not the needs are met. In addition, only with measurement can one answer questions such as, Is our quality getting better or worse? Are we competitive with others? Which one of our operations provides the best quality? How can we bring all operations up to the level of the best?

Units of Measure for Product Features. The first task in measurement is to identify the appropriate unit of measurement for each customer need. For product features, we know of no simple, convenient, generic formula that is the source of many units of measure. The number and variety of product features are simply enormous. In practice, each product feature requires its own unique unit of measure. A good starting point is to ask the customers what their units of measure are for evaluating product quality. If the supplier's units of measure are different, the stage is set for customer dissatisfaction, and the team will need to come up with a unit of measure acceptable to both parties. Even if the customers have not developed an explicit unit of measure, ask them how they would know whether the need were met. Their response may carry with it an implicit unit of measure.

Application to Goods. Units of measure for quality features of goods make extensive use of "hard" technological units. Some of these are well known to the public: time in minutes, temperature in degrees, or electric current in amperes. Many others are known only to the specialists.

There are also "soft" areas of quality for goods. Food technologists need units of measure for flavor, tenderness, and still other properties of food. Household appliances must be "handsome" in appearance. Packaging must be "attractive." To develop units of measure for such features involves much effort and ingenuity.

Application to Services. Evaluation of service quality includes some technological units of measure. A widespread example is promptness, which is measured in days, hours, and so on. Environmental pollutants (e.g., noise, radiation, etc.) generated by service companies are likewise measured using technological units of measure.

Service quality also involves features such as courtesy of service personnel, decor of surroundings, and readability of reports. Since these features are judged by human beings, the units of measure (and the associated sensors) must be shown to correlate with a jury of customer opinion.

The Ideal Unit of Measure. The criteria for an ideal unit of measure are summarized below. An ideal unit of measure

- Is understandable
- Provides an agreed basis for decision making
- Is conducive to uniform interpretation
- Is economical to apply
- Is compatible with existing designs of sensors, if other criteria also can be met

Measuring Abstractions. Some quality features seem to stand apart from the world of physical things. Quality of service often includes courtesy as a significant quality feature. Even in the case of physical goods, we have quality features, such as beauty, taste, aroma, feel, or sound. The challenge is to establish units of measure for such abstractions.

The approach to dealing with abstractions is to break them up into identifiable pieces. Once again, the customer may be the best source to start identifying these components. For example, hotel room appearance is certainly a quality feature, but it also seems like an abstraction. However, we can divide the feature into observable parts and identify those specifics which collectively constitute "appearance," e.g., the absence of spots or bare patches on the carpet, clean lavatory, linens free from discoloration and folded to specified sizes, windows free of streaks, bedspreads free of wrinkles and hanging to within specific distances from the floor, and so on. Once units of measure have been established for each piece or component, they should be summarized into an index, e.g., number of soiled or damaged carpets to total number of hotel rooms, number of rooms with missing linens to total number of rooms, or number of customer complaints.

Establish the Sensor. To say it in numbers, we need not only a unit of measure, but we also need to evaluate quality in terms of that unit of measure. A key element in making the evaluation is the sensor.

A "sensor" is a specialized detecting device or measurement tool. It is designed to recognize the presence and intensity of certain phenomena and to convert this sense knowledge into information. In turn, the resulting information becomes an input to decision making because it enables us to evaluate actual performance.

Technological instruments are obviously sensors. So are the senses of human beings. Trends in some data series are used as sensors. Shewhart control charts are sensors.

Precision and Accuracy of Sensors. The "precision" of a sensor is a measure of the ability of the sensor to reproduce its results over and over on repeated tests. For most technological sensors, this reproducibility is high and is also easy to quantify.

At the other end of the spectrum are the cases in which we use human beings as sensors: inspectors, auditors, supervisors, and appraisers. Human sensors are notoriously less precise than technological sensors. Such being the case, planners are well advised to understand the limitations inherent in human sensing before making decisions based on the resulting data.

The "accuracy" of a sensor is the degree to which the sensor tells the truth—the extent to which its evaluation of some phenomenon agrees with the "true" value as judged by an established standard. The difference between the observed evaluation and the true value is the "error," which can be positive or negative.

For technological sensors, it is usually easy to adjust for accuracy by recalibrating. A simple example is a clock or watch. The owner can listen to the time signals provided over the radio. In contrast, the precision of a sensor is not easy to adjust. The upper limit of precision is usually inherent in the basic design of the sensor. To improve precision beyond its upper limit requires a redesign. The sensor may be operating at a level of precision below that of its capability owing to misuse, inadequate maintenance, and so on. For this reason, when choosing the appropriate sensor for each need, planners will want to consider building in appropriate maintenance schedules along with checklists on actions to be taken during the check.

Translating and Measuring Mustang Customer Needs. The customer need for performance illustrates how high-level needs breakdown into a myriad of detailed needs. Performance included all the following detailed, precise needs:

Performance feel off the line

Wide-open throttle (WOT) 0 to 60 mi/h elapsed time

WOT $^{1}/_{4}$-mile elapsed time

WOT 40 to 60 mi/h passing time

WOT 30 to 70 mi/h passing time

Part-throttle response

Seat-of-the-pants feel that can only be measured by a jury of customers

Competitor performance was used as a minimum benchmark, but Ford knew that its competitors also were working on new models and had to stretch the needs analysis to include "what-if" scenarios that were tested with panels of consumers and automotive experts.

Product Design Spreadsheet. All the information on the translation and measurement of a customer need must be recorded and organized. Experience recommends placing these data so that they will be close at hand during product design. The example in Figure 3.9 shows a few needs all prepared for use in product design. The needs, their translation, and their measurement are all placed to the left of the spreadsheet. The remainder of the spreadsheet will be discussed in the next section.

STEP 4: DEVELOP PRODUCT

Once the customers and their needs are fully understood, we are ready to design the product that will meet those needs best. Product development is not a new function for a company. Most companies have some process for designing and bringing new products to market. In this step of the quality planning process, we will focus on the role of quality in product development and how that role combines with the technical aspects of development and design appropriate for a particular industry. Within product development, product design is a creative process based largely on technological or functional expertise.

The designers of products traditionally have been engineers, systems analysts, operating managers, and many other professionals. In the quality arena, designers can include any whose experience, position, and expertise can contribute to the design process. The outputs of product design are detailed designs, drawings, models, procedures, specifications, and so on.

The overall quality objectives for this step are two:

1. Determine which product features and goals will provide the optimal benefit for the customer
2. Identify what is needed so that the designs can be delivered without deficiencies.

Needs	Translation	Units of Measure	Sensors	Product Features: Cross resource checking	Auto search for open times	Check resource constraints	FAX information to scheduling source	Mail instructions to patient	●	●	●		
No double bookings	Double bookings	Yes/No	Review by scheduler	●									
Pt. comes prepared	Pt. followed MD's instructions	Yes/No/Partial	Review by person doing procedure				△	●					
All appointments used	No "holds" used	Yes/No	Review by scheduler		●	○							
All info. easy to find	Do not have to "search"	Yes/No	Review by scheduler		○								
Quick confirmation	Quick confirmation	Minutes	Software/Review by scheduler	○	○								
			Product Feature Goals:	100% of time for all information entered	One key stroke	Cannot change appt. w/o author from source	Reminder always generated for receiver	For all appointments	●				

Legend

- ● Very Strong
- ○ Strong
- △ Weak

FIGURE 3.9 Product design spreadsheet for outpatient appointment function. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

In the case of designing services, the scope of this activity is sometimes puzzling. For example, in delivering health care, where does the *product* of diagnosing and treating end and the *processes* of laboratory testing, chart reviews, and so on begin? One useful way to think about the distinction is that the *product* is the "face to the customer." It is what the customer sees and experiences. The patient sees and experiences the physician interaction, waiting time, clarity of information, and so on. The effectiveness and efficiency of moving blood samples to and around the laboratory have an effect on these product features but are really features of the process that delivers the ultimate product to the customer.

Those who are designing physical products also can benefit from thinking about the scope of product design. Remembering that the customer's needs are the benefits that the customer wants from the product, the design of a piece of consumer electronics includes not only the contents of the box itself but also the instructions for installation and use and the "help line" for assistance.

There are six major activities in this step:

- Group together related customer needs.
- Determine methods for identifying product features.
- Select high-level product features and goals.
- Develop detailed product features and goals.
- Optimize product features and goals.
- Set and publish final product design.

Group Together Related Customer Needs. Most quality planning projects will be confronted with a large number of customer needs. Based on the data developed in the preceding steps, the team can prioritize and group together those needs which relate to similar functionality. This activity does not require much time, but it can save a lot of time later. Prioritization ensures that the scarce resources of product development are spent most effectively on those items which are most important to the customer. Grouping related needs together allows the planning team to "divide and conquer," with subteams working on different parts of the design. Such subsystem or component approaches to design, of course, have been common for years. What may be different here is that the initial focus is on the *components of the customers' needs, not the components of the product.* The component design for the product will come during the later activities in this step.

Determine Methods for Identifying Product Features. There are many complementary approaches for identifying the best product design for meeting customers' needs. Most design projects do not use all of them. Before starting to design, however, a team should develop a systematic plan for the methods it will use in its own design. Here are some of the options.

Benchmarking. This approach identifies the best in class and the methods behind it that make it best. See Section 12 for details.

Basic Research. One aspect of research might be a new innovation for the product that does not currently exist in the market or with competitors. Another aspect of basic research looks at exploring the feasibility of the product and product features. While both these aspects are important, be careful that fascination with the technological abilities of the product do not overwhelm the primary concern of its benefits to the customer.

Market Experiments. Introducing and testing ideas for product features in the market allow one to analyze and evaluate concepts. The focus group is one technique that can be used to measure customer reactions and determine whether the product features actually will meet customer needs. Some organizations also try out their ideas, on an informal basis, with customers at trade shows and association meetings. Still others conduct limited test marketing with a prototype product.

Creativity. Developing product features allows one to dream about a whole range of possibilities without being hampered by any restrictions or preconceived notions. Quality planning is a proven, structured, data-based approach to meeting customers' needs. But this does not mean it is rigid and uncreative. At this point in the process, the participants in planning must be encouraged and given the tools they need to be creative so as to develop alternatives for design. After they have selected a number of promising alternatives, then they will use hard analysis and data to design the final product.

Planning teams can take advantage of how individuals view the world: from their own perspective. Every employee potentially sees other ways of doing things. The team can encourage people to suggest new ideas and take risks. Team members should avoid getting "stuck" or take too much time to debate one particular idea or issue. They can put it aside and come back to it later with a fresh viewpoint. They can apply new methods of thinking about customers' needs or problems, such as the following:

- *Changing key words or phrases.* For example, call a "need" or "problem" an "opportunity." Instead of saying, "deliver on time," say, "deliver exactly when needed."
- *Random association.* For example, take a common word such as "apple" or "circus" and describe your business, product, or problem as the word. For example, "Our product is like a circus because…"
- *Central idea.* Shift your thinking away from one central idea to a different one. For example, shift the focus from the product to the customer by saying, "What harm might a child suffer, and how can we avoid it?" rather than, "How can we make the toy safer?"
- *Putting yourself in the other person's shoes.* Examine the question from the viewpoint of the other person, your competitor, your customer—and build their case before you build your own.
- *Dreaming.* Imagine that you had a magic wand that you could wave to remove all obstacles to achieving your objectives. What would it look like? What would you do first? How would it change your approach?
- *The spaghetti principle.* When you have difficulty considering a new concept or how to respond to a particular need, allow your team to be comfortable enough to throw out a new idea, as if you were throwing spaghetti against the wall, and see what sticks. Often even "wild" ideas can lead to workable solutions.

The initial design decisions are kept as simple as possible at this point. For example, the idea of placing the control panel for the radio on the steering wheel would be considered a high-level product feature. Its exact location, which controls, and how they function can be analyzed later in more detail. It may become the subject of more detailed product features as the planning project progresses.

Standards, Regulations, and Policies. This is also the time to be certain that all relevant standards, regulations, and policies have been identified and addressed. While some of these requirements are guidelines for how a particular product or product feature can perform, others mandate how they must perform. These may come from inside the organization, and others may come from specific federal, state, or local governments, regulatory agencies, or industry associations. All product features and product feature goals must be analyzed against these requirements before making the final selection of product features to be included in the design.

It is important to note that if there is a conflict when evaluating product features against any standards, policies, or regulations, it is not always a reason to give up. Sometimes one can work to gain acceptance for a change when it will do a better job of meeting customer needs. This is especially true when it comes to internal policies. However, an advocate for change must be prepared to back the arguments up with the appropriate data.

Criteria for Design. As part of the preparation for high level design, the design team must agree on the explicit criteria to be used in evaluating alternative designs and design features. All designs must fulfill the following general criteria:

- Meet the customers' needs
- Meet the suppliers' and producers' needs
- Meet (or beat) the competition
- Optimize the combined costs of the customers and suppliers

In addition to the preceding four general criteria, the team members should agree explicitly on the criteria that it will use to make its selection. (If the choices are relatively complex, the team should consider using the formal discipline of a selection matrix.) One source for these criteria will be the team's mission statement and goals. Some other types of criteria the team may develop include

- The impact of the feature on the needs
- The relative importance of the needs being served
- The relative importance of the customers whose needs are affected
- The feasibility and risks of the proposed feature
- The impact on product cost
- The relationship to competitive features uncovered in benchmarking
- The requirements of standards, policies, regulations, mandates, and so on

As part of the decision on how to proceed with design, teams also must consider a number of other important issues regarding what type of product feature will be the best response to customers' needs. When selecting product features, they need to consider whether to

- Develop an entirely new functionality
- Replace selected old features with new ones
- Improve or modify existing features
- Eliminate the unnecessary

Regulations and Standards for Ford's Mustang. The Federal Motor Vehicle Safety Standards (FMVSS) are, of course, a prime concern for designing any automobile. Ford had established its own safety standards that were more extensive than the federal mandates and included a significant margin of additional safety on all quantitative standards.

Select High-Level Product Features and Goals. This phase of quality planning will stimulate the team to consider a whole array of potential product features and how each would respond to the needs of the customer. This activity should be performed without being constrained by prior assumptions or notions as to what worked or did not work in the past. A response that previously failed to address a customer need or solve a customer problem might be ready to be considered again because of changes in technology or the market.

The team begins by executing its plan for identifying the possible product features. It should then apply its explicit selection criteria to identify the most promising product features.

The product design spreadsheet in Figure 3.9 is a good guide for this effort. Use the right side of the spreadsheet to determine and document the following:

- Which product features contribute to meeting which customer needs
- That each priority customer need is addressed by at least one product feature
- That the total impact of the product features associated with a customer need is likely to be *sufficient* for meeting that need
- That every product feature contributes to meeting at least one significant customer need
- That every product feature is *necessary* for meeting at least one significant customer need (i.e., removing that feature would leave a significant need unmet)

Now the team must set goals for each feature. In quality terms, a goal is an aimed-at quality target (such as aimed-at values and specification limits). As discussed earlier, this differs from quality standards in that the standard is a mandated model to be followed that typically comes from an external source. While these standards serve as "requirements" that usually dictate uniformity or how the product is to function, product feature goals are often voluntary or negotiated. Therefore, the quality planning process must provide the means for meeting both quality standards and quality goals.

Criteria for Setting Product Feature Goals. As with all goals, product feature goals must meet certain criteria. While the criteria for establishing product feature goals differ slightly from the criteria for project goals verified in step 1, there are many similarities. Product feature goals should encompass all the important cases and be

- Measurable
- Optimal
- Legitimate
- Understandable
- Applicable
- Attainable

Measuring Product Features Goals. Establishing the measurement for a product feature goal requires the following tasks:

- Determine the unit of measure: meters, seconds, days, percentages, and so on.
- Determine how to measure the goal (i.e., determine what is the sensor).
- Set the value for the goal.

The work done in measuring customer needs should be applied now. The two sets of measurements may be related in one of the following ways:

- Measurement for the need and for the product feature goal may use the same units and sensors. For example, if the customer need relates to timeliness measured in hours, one or more product features normally also will be measured in hours, with their combined effects meeting the customer need.
- Measurement for the product feature may be derived in a technical manner from the need measurement. For example, a customer need for transporting specified sizes and weights of loads may be translated into specific engineering measurements of the transport system.
- Measurement for the product feature may be derived from a customer behavioral relationship with the product feature measure. For example, automobile manufacturers have developed the specific parameters for the dimensions and structure of an automobile seat that translate into the customer rating it "comfortable."

Since we can now measure both the customer need and the related product feature goals, it is possible for the quality planning team to ensure that the product design will go a long way toward meeting the customers' needs, even before building any prototypes or conducting any test marketing.

For large or complex projects, the work of developing product features is often divided among a number of different individuals and work groups. After all these groups have completed their work, the overall quality planning team will need to integrate the results. Integration includes

- Combining product features when the same features have been identified for more than one cluster
- Identifying and resolving conflicting or competing features and goals for different clusters
- Validating that the combined design meets the criteria established by the team

Develop Detailed Product Features and Goals. For large and highly complex products, it will usually be necessary to divide the product into a number of components and even subcomponents for detailed design. Each component will typically have its own design team that will complete the detailed design described below. In order to ensure that the overall design remains integrated, consistent, and effective in meeting customer needs, these large, decentralized project require

- A steering or core team that provides overall direction and integration
- Explicit charters with quantified goals for each component
- Regular integrated design reviews for all components
- Explicit integration of designs before completion of the product design phase

Once the initial detailed product features and goals have been developed, then the technical designers will prepare a preliminary design, with detailed specifications. This is a necessary step before a team can optimize models of product features using a number of quality planning tools and ultimately set and publish the final product features and goals.

It is not uncommon for quality planning teams to select product features at so high a level that they are not specific enough to respond to precise customer needs. Just as in the identification of customers' primary needs, high-level product features need to be broken down further into terms that are clearly defined and which can be measured.

Optimize Product Features and Goals. Once the preliminary design is complete, it must be optimized. That is, the design must be adjusted so that it meets the needs of both customer and supplier while minimizing their combined costs and meeting or beating the competition.

Finding the optimum can be a complicated matter unless it is approached in an organized fashion and follows quality disciplines. For example, there are many designs in which numerous variables converge to produce a final result. Some of these designs are of a business nature, such as design of an information system involving optimal use of facilities, personnel, energy, capital, and so on. Other such designs are technological in nature, involving optimizing the performance of hardware. Either way, finding the optimum is made easier through the use of certain quality disciplines.

Finding the optimum involves balancing the needs, whether they are multicompany needs or within-company needs. Ideally, the search for the optimum should be done through the participation of suppliers and customers alike. There are several techniques that help achieve this optimum.

Design Review. Under this concept, those who will be affected by the product are given the opportunity to review the design during various formative stages. This allows them to use their experience and expertise to make such contributions as

- Early warning of upcoming problems
- Data to aid in finding the optimum
- Challenge to theories and assumptions

Design reviews can take place at different stages of development of the new product. They can be used to review conclusions about customer needs and hence the product specifications (characteristics of product output). Design reviews also can take place at the time of selecting the optimal product design. Typical characteristics of design reviews include the following:

- Participation is mandatory.
- Reviews are conducted by specialists, external to the planning team.
- Ultimate decisions for changes remain with the planning team.
- Reviews are formal, scheduled, and prepared for with agendas.
- Reviews will be based on clear criteria and predetermined parameters.
- Reviews can be held at various stages of the project.

Ground rules for good design reviews include

- Adequate advance planning of review agenda and documents
- Clearly defined meeting structure and roles
- Recognition of interdepartmental conflicts in advance
- Emphasis on constructive, not critical, inputs
- Avoidance of competitive design during review
- Realistic timing and schedules for the reviews
- Sufficient skills and resources provided for the review
- Discussion focus on untried/unproved design ideas
- Participation directed by management

Joint Planning. Planning teams should include all those who have a vested interest in the outcome of the design of the product along with individuals skilled in product design. Under this concept, the team, rather than just the product designers, bears responsibility for the final design.

Structured Negotiation. Customers and suppliers are tugged by powerful local forces to an extent that can easily lead to a result other than the optimum. To ensure that these negotiating sessions proceed in as productive a fashion as possible, it is recommended that ground rules be established before the meetings. Here are some examples:

- The team should be guided by a spirit of cooperation, not competition, toward the achievement of a common goal.
- Differences of opinion can be healthy and can lead to a more efficient and effective solution.
- Everyone should have a chance to contribute, and every idea should be considered.
- Everyone's opinions should be heard and respected without interruptions.
- Avoid getting personal; weigh pros and cons of each idea, looking at its advantages before its disadvantages.
- Challenge conjecture; look at the facts.
- Whenever the discussion bogs down, go back and define areas of agreement before discussing areas of disagreement.
- If no consensus can be reached on a particular issue, it should be tabled and returned to later on in the discussion.

Create New Options. Often teams approach a product design with a history of how things were done in the past. Optimization allows a team to take a fresh look at the product and create new options. Some of the most common and useful quality tools for optimizing the design include the following:

Competitive analysis provides feature-by-feature comparison with competitors' products. (See the following for an example.)

Salability analysis evaluates which product features stimulate customers to be willing to buy the product and the price they are willing to pay. (See the following for an example.)

Value analysis calculates not only the incremental cost of specific features of the product but also the cost of meeting specific customer needs and compares the costs of alternative designs. (See the following for an example.)

Criticality analysis identifies the "vital few" features that are vulnerable in the design so that they can receive priority for attention and resources.

Failure mode and effect analysis (*FMEA*) calculates the combined impact of the probability of a particular failure, the effects of that failure, and the probability that the failure can be detected and corrected, thereby establishing a priority ranking for designing in failure-prevention countermeasures. (See Section 19 under Reliability Analysis.)

Fault-tree analysis aids in the design of preventive countermeasures by tracing all possible combinations of causes that could lead to a particular failure. (See Section 19 under Reliability Analysis; also see Section 48.)

Design for manufacture and assembly evaluates the complexity and potential for problems during manufacture to make assembly as simple and error-free as possible. Design for maintainability evaluates particular designs for the ease and cost of maintaining them during their useful life.

Competitive Analysis. Figure 3.10 is an example of how a competitive analysis might be displayed. The data for a competitive analysis may require a combination of different approaches such as laboratory analysis of the competitors' products, field testing of those products, or in-depth interviews and on-site inspections where willing customers are using a competitor's product.

Note that by reviewing this analysis, the planning team can identify those areas in which the design is vulnerable to the competition, as well as those in which the team has developed an advantage. Based on this analysis, the team will then need to make optimization choices about whether to upgrade the product or not. The team may need to apply a value analysis to make some of these choices.

Salability Analysis. An example of salability analysis is shown in Figure 3.11. This analysis is similar to a competitive analysis, except that the reference point is the response of customers to the proposed design rather than a comparison with the features of the competitors' designs. Note, however, that elements of competitive and salability analyses can be combined, with the salability analysis incorporating customer evaluation of both the proposed new design and existing competitive designs.

Complex products, such as automobiles, with multiple optional features and optional configurations offer a unique opportunity to evaluate salability. Observed installation rates of options on both the existing car line and competitors' cars provide intelligence on both the level of market demand for the feature and the additional price that some segments of the market will pay for the feature—although the other segments of the market may place little or no value on it.

Value Analysis. Value analysis has been quite common in architectural design and the development of custom-engineered products, but it also can be applied successfully to other environments as well, as illustrated in Figure 3.12. By comparing the costs for meeting different customer needs, the design team can make a number of significant optimization decisions. If the cost for meeting low-priority needs is high, the team must explore alternative ways to meet those needs and even consider not addressing them at all if the product is highly price sensitive. If very important needs have not consumed much of the expense, the team will want to make certain that it has met those needs fully and completely. While low expense for meeting a high-priority need is not necessarily inappropriate, it does present the designers with the challenge of making certain that lower-priority needs are not being met using resources that could be better directed toward the higher-priority needs. It is not uncommon for products to be overloaded with "bells and whistles" at the expense of the fundamental functionality and performance.

Mustang's Performance Features. One of the critical challenges for engineering the performance of Mustang was to develop the ideal power-to-weight ratio that would meet the performance needs of the customers. However, as is the case with most ratios of this sort, the ratio can be improved either by reducing the weight or by increasing the power. What is more, fuel economy is also affected by the weight.

Design trade-offs among weight, power, and fuel economy involved not only detailed engineering calculations but also careful assessments of customer reactions and the competing views of different functions within the company. Reaching a final design that met the customer needs and fulfilled sound engineering principles required strong project leadership in addition to the data.

Product Feature & Goal	Check if Product Feature is Present			Feature Performance vs. Goal (*)			Identify if Significant Risk or Opportunity
	Product A	Product B	Ours	Product A	Product B	Ours	
Retreive messages from all touch tone phones easily	Yes	Yes	Yes	4	5	4	—
Change message from any remote location	Yes	No	Yes	3	—	5	O
2 lines built in	No	No	Yes	—	—	4	O

Below Add Features in Competitors Product Not Included in Ours	Check if Product Feature is Present			Feature Performance vs. Goal (*)			Identify if Significant Risk or Opportunity
	Product A	Product B	Ours	Product A	Product B	Ours	
No cassette used to record message	Yes	Yes		4	—		R
Telephone and answering machine in one unit	Yes	Yes		3	4		R

FIGURE 3.10 Competitive analysis. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Name of Product Car Repair Service—Tune-up	How Do Customers Rate Product? Poor Fair Satisfactory Good Excellent	Basis for Rating Prior Use vs. Opinion	How Do Customers See Differences Between Our Products and Competing Products?	Would Customers Buy If Price Were Not Important? Yes No	Would Customer Buy If Price Were Important?		Of All Products Listed, Prioritize Which Would Customers Buy and Its Basis? Price Features	Identify if Significant Risk or Opportunity
					Price	Yes No		
Ours—	E	U		Y	$175	Y	2-F	
Competitor A—	G	O	+	N	$145	Y	3-P	O
Competitor B—	E	U	O	Y	$175	Y	1-F	R

Name of Product Pick-up and delivery of car to be repaired Product Feature Goal: Same Day Service	How Do Customers Rate Product? Poor Fair Satisfactory Good Excellent	Basis for Rating Prior Use vs. Opinion	How Do Customers See Differences Between Our Features Against Competing Features? Positively (+) Negatively (–) No Difference	Does the Addition of the Feature Make the Product: More Salable Less Salable No Difference	Identify if Significant Risk or Opportunity
Ours—Offered	G	U		O	
Competitor A—Not Offered	S	O	+	—	O
Competitor B—Offered. Also provides loaner car to customer	E	U	—	+	R

FIGURE 3.11 Salability analysis for automobile maintenance service. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Product: Store Front Prenatal Clinic

Customer Need (listed in priority order)	Product Feature & Goals						Cost of Meeting Need
	Walk in appointments handled by Nurse, 5 days a week	Board Certified Obstetrician, 2 days a week	Social Worker, 5 days a week	Nutritional Counselor, 5 days a week	On-site Billing Clerk takes Medicaid insurance from all eligible patients	On-site laboratory most results under 1 hour	
Convenient to use	60,000	30,000	10,000	10,000	20,000	40,000	170,000
Confidence in staff		70,000	10,000	15,000			95,000
Reasonable cost						25,000	25,000
Sensitivity			5,000	5,000			20,000
Informed choices			15,000	15,000			20,000
Cost for Feature	60,000	100,000	40,000	45,000	20,000	65,000	330,000

FIGURE 3.12 Value analysis for prenatal clinic. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

Set and Publish Final Product Design. After the design has been optimized and tested, it is time to select the product features and goals to be included in the final design. This is also the stage where the results of product development are officially transmitted to other functions through various forms of documentation. These include the specifications for the product features and product feature goals, as well as the spreadsheets and other supporting documents. All this is supplemented by instructions, both oral and written. To complete this activity, the team must first determine the process for authorizing and publishing product features and product feature goals. Along with the features and goals, the team should include any procedures, specifications, flow diagrams, and other spreadsheets that relate to the final product design. The team should pass along results of experiments, field testing, prototypes, and so on, that are appropriate. If an organization has an existing process for authorizing product goals, it should be reexamined in light of recent experience. Ask these questions, Does the authorization process guarantee input from key customers—both internal and external? Does it provide for optimization of the design? If an organization has no existing goal authorization process, now is a good time to initiate one.

STEP 5: DEVELOP PROCESS

Once the product is developed, it is necessary to determine the means by which the product will be created and delivered on a continuing basis. These means are, collectively, the "process." "Process development" is the set of activities for defining the specific means to be used by operating personnel for meeting product quality goals. Some related concepts include

Subprocesses: Large processes may be decomposed into these smaller units for both the development and operation of the process.

Activities: The steps in a process or subprocess.

Tasks: The detailed step-by-step description for execution of an activity.

In order for a process to be effective, it must be goal oriented, with specific measurable outcomes; systematic, with the sequence of activities and tasks fully and clearly defined and all inputs and outputs fully specified; and capable, i.e., able to meet product quality goals under operating conditions and legitimate, with clear authority and accountability for its operation.

The eleven major activities involved in developing a process are

- Review product goals.
- Identify operating conditions.
- Collect known information on alternate processes.
- Select general process design.
- Identify process features and goals.
- Identify detailed process features and goals.
- Design for critical factors and human error.
- Optimize process features and goals.
- Establish process capability.
- Set and publish final process features and goals.
- Set and publish final process design.

Review Product Goals. Ideally, this review will be relatively simple. Product quality goals should have been validated with the prior participation of those who would be affected. In many companies, however, product and process design often are executed by different teams. There is no real joint participation on either group's part to contribute to the results that both the teams are expected to produce. This lack of participation usually reduces the number of alternative designs that could have been readily adopted in earlier stages but become more difficult and more expensive to incorporate later. In addition, those who set the product goals have a vested interest in their own decisions and exhibit cultural resistance to proposals by the process design team to make changes to the product design. If the product and process design efforts are being performed by different groups, then review and confirmation of the product quality goals are absolutely critical.

Review of product quality goals ensures that they are understood by those most affected by the process design. The review helps achieve the optimum. Process designers are able to present product designers with some realities relative to the costs of meeting the quality goals. The review process should provide a legitimate, unobstructed path for challenging costly goals.

Identify Operating Conditions. Seeking to understand operating conditions requires investigation of a number of dimensions.

User's Understanding of the Process. By "users," we mean those who either contribute to the processes in order to meet product goals or those who employ the process to meet their own needs. Users consist, in part, of internal customers (organization units or persons) responsible for running the processes to meet the quality goals. Operators or other workers are users. Process planners need to know how these people will understand the work to be done. The process must be designed either to accommodate this level of understanding or to improve the level of understanding.

How the Process Will be Used. Designers always know the *intended* use of the process they develop. However, they may not necessarily know how the process is *actually* used (and misused) by the end user. Designers can draw on their own experiences but usually must supplement these with direct observation and interviews with those affected.

The Environments of Use. Planners are well aware that their designs must take account of environments that can influence process performance. Planners of physical processes usually do take account of such environmental factors as temperature, vibration, noise level, and so on. Planners who depend heavily on human responses, particularly those in the service areas, should address the impact of the environment on human performance in their process designs. For example, a team designing the process for handling customer inquiries should consider how environmental stress can influence the performance of the customer service representatives. This stress can result from large numbers of customer complaints, abusive customers, lack of current product information, and so on.

Collect Known Information on Alternative Processes. Once the goals and environment are clear, the planning team needs reliable information on alternative processes available for meeting those goals in the anticipated environment.

Process Anatomy. At the highest level, there are some basic process anatomies that have specific characteristics that planners should be aware of. A "process anatomy" is a coherent structure that binds or holds the process together. This structure supports the creation of the goods or the delivery of the service. The selection of a particular anatomy also will have a profound influence on how the product is created and the ability of the organization to respond to customers' needs. Figure 3.13 illustrates these.

The Autonomous Department. The "autonomous process" is defined as a group of related activities that are usually performed by one department or a single group of individuals. In this process form, the department or group of individuals receives inputs from suppliers, such as raw materials, parts, information, or other data, and converts them into finished goods and services, all within a single self-contained department.

An example of an autonomous process is the self-employed professional, e.g., a physician, consultant, or artisan. In financial services, it might be the loan-approval department. In manufacturing, a well-known example is a tool room. It starts with tool steel and engineering drawings and creates punches, dies, fixtures, and gauges to be used on the manufacturing floor. Even though we refer to this kind of process anatomy as "autonomous," outputs or deliverables from other processes are still required from outside sources that serve as inputs into this process. The self-employed physician, for example, may purchase equipment and materials from supply houses, pharmaceutical companies, and so on.

The Assembly Tree. The "assembly tree" is a familiar process that incorporates the outputs of several subprocesses. Many of these are performed concurrently and are required for final assembly or to achieve an end result at or near the end of the process. This kind of process anatomy is widely used by the great mechanical and electronic industries that build automotive vehicles, household appliances, electronic apparatus, and so on. It is also used to define many processes in a hospital, such as in the case of performing surgery in the operating room. The branches or leaves of the tree represent numerous suppliers or in-house departments making parts and components. The elements are assembled by still other departments.

In the office, certain processes of data collection and summary also exhibit features of the assembly tree. Preparation of major accounting reports (e.g., balance sheet, profit statement) requires assembly of many bits of data into progressively broader summaries that finally converge into the consolidated reports. The assembly-tree design has been used at both the multifunctional and departmental levels. In large operations, it is virtually mandatory to use staff specialists who contribute different outputs at various multifunctional levels. An example of this is the budget process. While it is not mandatory to use staff specialists for large departmental processes, this is often the case. This can be illustrated by the design department, where various design engineers contribute drawings of a project that contribute to the overall design.

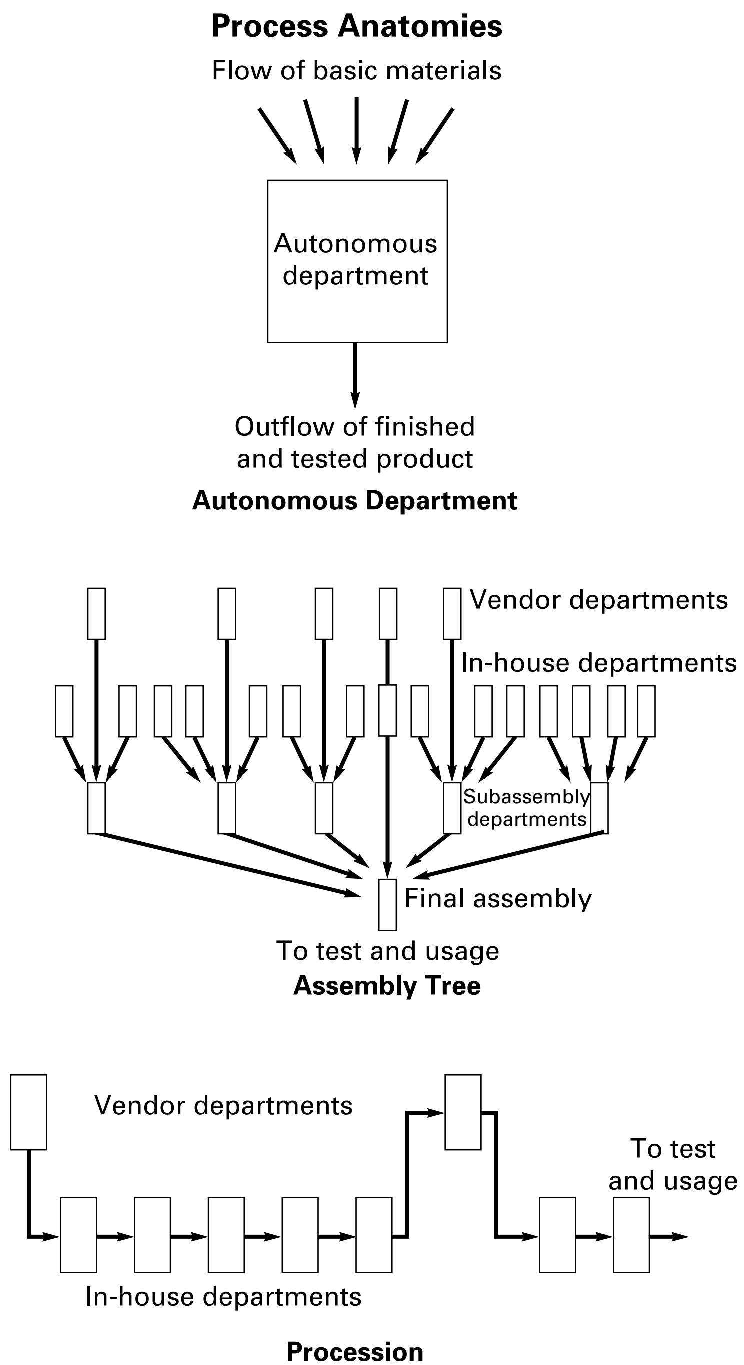

FIGURE 3.13 Process anatomies. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

The Procession. Another familiar form, the "procession process," uses a sequential approach as the basis for the process. This differs from the assembly tree, in which many of the activities are performed concurrently. The procession approach tends to take a more linear approach, whereby the lower-level processes are performed sequentially. It mandates that certain activities must be completed before others can begin because the outputs of each of the subprocesses serve as the inputs for each succeeding subprocess.

The intent of selecting a process anatomy is to determine the overall structure or architecture of the process that produces the product features and meets product feature goals. It does not necessarily follow that choosing one process anatomy over another locks the team into using that same architecture exclusively throughout the entire system. Quite the contrary, the team may select the assembly-tree process as the structure for the overall system but use a combination of autonomous and procession anatomies as the basis for subprocesses at the functional, departmental, or unit level.

Process Quality Management. Increasingly, many planners are applying a fourth, less traditional form of management known as "process quality management" to their major processes. This new, alternative management form has come about in response to an increased realization that many of today's business goals and objectives are becoming even more heavily dependent on large, complex, cross-functional business processes. Process quality management emphasizes that there are several critical processes that are crucial to an organization if it is to maintain and grow its business. (See Section 6 for a full discussion.)

Measuring the Process. In selecting a specific process design, the team will need to acquire information on the effectiveness and efficiency of alternative designs, including

- Deficiency rates
- Cycle time
- Unit cost
- Output rate

To acquire the needed data, the planners must typically use a number of different approaches, including

- Analyzing the existing process
- Analyzing similar or related processes
- Testing alternative processes
- Analyzing new technology
- Acquiring information from customers
- Simulating and estimating
- Benchmarking

Select General Process Design. Just as product design began with a high-level description expanded to the details, process design should begin by describing the overall process flow with a high-level process-flow diagram. From this diagram it will be possible to identify the subprocesses and major activities that can then be designed at a more detailed level. In developing the high-level flow, as well as the greater detail later, the team should ensure that it meets the following criteria:

- Will deliver the quality goals for the product
- Incorporates the countermeasures for criticality analysis, FMEA, and fault-tree analysis
- Meets the project goals
- Accounts for actual, not only intended, use
- Is efficient in consumption of resources
- Demands no investments that are greater than planned

While some process designs will largely repeat existing designs and some others will represent "green field" or "blank sheet" redesigns, most effective process redesigns are a combination of the tried and true existing processes with some significant quantum changes in some parts of the process. The preceding criteria should be the guides for whether a particular part of the process should be incorporated as it is, improved, or replaced with a fundamentally different approach.

This is the point in process design to think as creatively as possible, using some of the same techniques discussed under product development. Consider the impact of radically different anatomies. Would the customer be served better with dedicated, multispecialty units or with highly specialized expert functionality accessed as needed? What approach is mostly likely to reduce deficiencies? How can cycle time by cut dramatically? Is there a new technology that would allow us to do it differently? Can we develop such a technology?

Once the high-level flow is completed, each activity and decision within the flow diagram needs to be fully documented with a specification of the following for each:

- Inputs
- Outputs
- Goals for outputs
- Cycle time
- Cost
- General description of the conversion of inputs to outputs

Clear specification of these factors makes it possible to divide up the work of detailed design later and still be confident that the final design will be consistent and coordinated.

Once the initial new process flow is completed, it should be reviewed for opportunities to improve it, such as

- Eliminate sources of error that lead to rework loops.
- Eliminate or reduce redundant subprocesses, activities, or tasks.
- Decrease the number of handoffs.
- Reduce cycle time.
- Replace tasks, activities, or processes that have outputs with defects.
- Correct sequencing issues in the process to reduce the amount of activity or rework.

Carryover of Process Designs. For each subprocess or major activity, one of the following questions must be answered in the affirmative:

If it is a carryover design, is the process capable of meeting the product quality goals?

If it is a new design, can we demonstrate that it is at least as effective at meeting product quality goals while also maintaining or improving cost and cycle time?

Testing Selected Processes. One of the key factors for a successful design is incorporating the lessons learned from testing the product, the product features, and the overall process and subprocesses to ensure that they meet quality goals. Testing should be conducted throughout the entire quality planning process to allow for changes, modifications, and improvements to the plan before it is transferred to operations. Testing is performed at various points to analyze and evaluate alternate designs of the overall process and subprocesses.

There are a number of options for testing the efficiency and effectiveness of a process prior to full-scale implementation. They include the following:

Pilot test: A pilot test tests the overall process on a small scale or with a small segment of the total population. The segment to receive testing will vary depending on the process itself. Testing may be limited to a particular location, department, or function.

Modular test: Sometimes it is not possible to test the entire process at one time, but it may be possible to test crucial elements of the process separately. A modular test is a test of individual segments of the process. Generally, the outputs of certain subprocesses influence the ability of other processes to perform efficiently and effectively. These critical processes require their own tests to isolate problems that may occur and allow improvements to be made.

Simulation: This design technique observes and manipulates a mathematical or physical model that represents a real-world process for which, for technical or economic reasons, direct experimentation is not possible. Different circumstances can be applied to test how the process will perform under varying conditions, inputs, and worst-case scenarios.

Dry run: A dry run is a walk-through of the new process, with the planning team playing a dominant operating role in the process. This is a test of the process under operating conditions. The purpose is to test the process. Any resulting product is not sent to customers. Usually the team has worked so closely with designing the process that it can lose sight of how the various pieces actually fit together. The dry run gives the team one last opportunity to step back and see, from a conceptual standpoint, whether the process can work as designed before other tests are performed or before the process is transferred to operations.

Acceptance test: This is a highly structured form of testing common in complex systems, such as computer systems. A test plan is designed by a special team not directly involved in the design of the process being tested. The test plan sets up the proper environmental conditions, inputs, relevant interventions, and operating conditions. The test is intended to stress, in relevant ways, the important functional and other features in which the process could fail. In some cases, it is vital that the new process design be tested under operating conditions by the people who will actually operate it—assuming they are different from the planning team. The team may not have understood problem operating conditions; there may be unforeseen problems or resistance that cannot be overcome. Without such a test, these factors could contribute to a very costly mistake. Therefore, in such cases, acceptance testing under real conditions is essential.

Comparisons or benchmarks. Other units inside and outside the organization may already be using a process similar to the one designed. The process can be validated by comparing it with existing similar processes.

Test Limitations. All tests have some limitations. The following are common limitations that should be understood and addressed.

Differences in operating conditions: Dry runs and modular testing obviously differ from operating conditions. Even pilot tests and benchmarks will differ in some details from the actual, full implementation. Some common differences between conditions for testing and conditions for full-scale use include

- People operating the process
- Customers of the process
- Extreme values and unusual conditions
- Interactions with other processes and other parts of the organization.

Differences in size: Especially with critical failures, such as breakdown of equipment, loss of key personnel, or any other potential failure, as in the case of complications in a surgical procedure, a test might not be large enough to allow these rare failures to occur with any high degree of certainty.

Cultural resistance: Cultural reactions to tests differ from reactions to permanent changes. Such reactions might be either more or less favorable than full-scale implementation. Tests may go well because they lack the cultural impact of full implementation. They may go poorly because participants will not give the test the same careful attention they would give the "real" work.

Other effects. Sometimes designing a new process or redesigning an existing process may create or exacerbate problems in other processes. For example, improved turnaround time in approving home loans may create a backlog for the closing department. Such interactions among processes might not occur in an isolated test.

Identify Process Features and Goals. A "process feature" is any property, attribute, and so on that is needed to create the goods or deliver the service and achieve the product feature goals that will satisfy a customer need. A "process goal" is the numeric target for one of the features.

Whereas product features answer the question, "What characteristics of the product do we need to meet customers needs?" process features answer the question, "What mechanisms do we need to create or deliver those characteristics (and meet quality goals) over and over again without deficiencies?" Collectively, process features define a process. The flow diagram is the source of many, but not all, of these features and goals.

As the process design progresses from the macro level down into details, a long list of specific process features emerges. Each of these is aimed directly at producing one or more product features. For example:

- Creating an invoice requires a process feature that can perform arithmetic calculations so that accurate information can be added.
- Manufacturing a gear wheel requires a process feature that can bore precise holes into the center of the gear blank.
- Selling a credit card through telemarketing requires a process feature that accurately collects customer information

Most process features fall into one of the following categories:

- *Procedures*—a series of steps followed in a regular, definite order
- *Methods*—an orderly arrangement of a series of tasks, activities, or procedures
- *Equipment and supplies*—"physical" devices and other hard goods that will be needed to perform the process
- *Materials*—tangible elements, data, facts, figures, or information (these, along with equipment and supplies, also may make up inputs required as well as what is to be done to them)
- *People*—numbers of individuals, skills they will require, goals, and tasks they will perform
- *Training*—skills and knowledge required to complete the process
- *Other resources*—additional resources that may be needed
- *Support processes*—can include secretarial support, occasionally other support, such as outsources of printing services, copying services, temporary help, and so on.

Just as in the case of product design, process design is easier to manage and optimize if the process features and goals are organized into a spreadsheet indicating how the process delivers the product features and goals. Figure 3.14 illustrates such a spreadsheet.

The spreadsheet serves not only as a convenient summary of the key attributes of the process, it also facilitates answering two key questions that are necessary for effective and efficient process design. First, will every product feature and goal be attained by the process? Second, is each process feature absolutely necessary for at least one product feature; i.e., are there any unnecessary or redundant process features? Also, verify that one of the other process features cannot be used to create the same effect on the product.

Often high-level process designs will identify features and goals that are required from companywide macro processes. Examples might include cycle times from the purchasing process, specific data from financial systems, and new skills training. Because the new process will depend on these macro processes for support, now is the time to verify that they are capable of meeting the goals. If they are not, the macro processes will need to be improved as part of the process design, or they will need to be replaced with an alternative delivery method.

Identify Detailed Process Features and Goals. In most cases, it will be most efficient and effective for individual subteams to carry out the detailed designs of subprocesses and major

		Process Features			
Product Feature	**Product Feature Goal**	Spray delivery capacity	Crew Size	Certified materials	Scheduling forecast on P.C. to determine to/from and work needed
Time to perform job	Less than one hour 100 percent of time	○	●		●
Guaranteed appointment time	99 percent of jobs within 15 minutes of appointment				●
All materials environmentally safe	All naturally occuring/no synthetics			●	
	Process Feature Goals	10 gallons per minute	One person per 10,000 sq. ft. of yd.	100% approved by State Dept. of Agriculture	Forecast time always within 10 percent of actual

Legend

● Very Strong
○ Strong
△ Weak

FIGURE 3.14 Process design spreadsheet for a lawn care service. (*Juran Institute, Inc. Copyright 1994. Used by permission.*)

activities. These detailed designs will have the process features and goals as their objectives and criteria. Each subprocess team will develop the design to the level at which standard operating procedures can be developed, software coded, equipment produced or purchased, and materials acquired.

Design for Critical Factors and Human Error. One key element of process design is determining the effect that critical factors will have on the design. "Critical factors" are those aspects which present serious danger to human life, health, and the environment or risk the loss of very large sums of money. Some examples of such factors involve massive scales of operations: airport traffic control systems, huge construction projects, systems of patient care in hospital, and even the process for managing the stock market. Planning for such factors should obviously include ample margins of safety as to structural integrity, fail-safe provisions, redundancy systems, multiple alarms, and so on. Criticality analysis and failure-mode and effect analysis (see Section 19) are helpful tools in identifying those factors which require special attention at this point.

Workers vary in their capabilities to perform specific tasks and activities. Some workers perform well, whereas others do not perform nearly as well. What is consistent about all workers is that they are a part of the human family, and human beings are fallible. Collectively, the extent of human errors is large enough to require that the process design provides for means to reduce and control human error. Begin by analyzing the data on human errors, and then apply the Pareto principle. The vital few error types individually become candidates for special process design. The human errors that can be addressed by process design fall into these major classes:

- Technique errors arising from individuals lacking specific, needed skills
- Errors aggravated by lack of feedback
- Errors arising from the fact that humans cannot remain indefinitely in a state of complete, ready attention

Technique Errors. Some workers consistently outperform others on specific quality tasks. The likely reason is possession of a special "knack." In such cases, designers should study the methods used by the respective workers to discover the methodologic differences. These differences usually include the knack—a small difference in method that produces a big difference in performance. Once the knack is discovered, the process designers can arrange to include the knack in the technology. Alternatively, the knack can be brought into the workers' training program so that all workers are brought up to the level of the best.

Lack of Instant Feedback. A useful principle in designing human tasks is to provide instant feedback to the worker so that the performance of the work conveys a message about the work to the worker. For example, a worker at a control panel pushes a switch and receives three feedbacks: the feel of the shape of the switch handle, the sound of an audible click signaling that the switch went all the way, and the sight of a visual illumination of a specific color and shape. Providing such feedback is part of self-control and allows the worker to modify his or her performance to keep the process within its quality goals.

Human Inattention Errors. A technique for designing human work is to require human attention as a prerequisite for completing the work; i.e., the task cannot be performed unless the person doing it devotes attention to it and to nothing else. A widespread case in point is inspection of documents, products, or whatever. Human checking can be done in two very different ways.

By passive deeds: Listening, looking, reading. Such deeds are notoriously subject to lapses in human attention. Also, such deeds leave no trail behind them. We have no way of knowing whether the human being in question is really paying attention or is in a state of inattention. For example, a person providing visual inspection of a product moving along an assembly line or someone proofreading a report may become fatigued. They can easily experience a momentary lapse in their attention, causing them to miss spotting a defect or to fail to notice that a column of numbers does not add up correctly.

By active deeds: Operating a keyboard, writing, spelling. Such deeds cannot be performed at all without paying attention to the task at hand and to the exclusion of all else. These active deeds do leave a trail behind them. They are therefore far less error-prone than passive checking. An example would be someone having to attach the leads of a voltage meter to a circuit board to check its resistance or a blood bank technician retesting each sample to verify blood type.

Inadvertent human errors and other types of errors can also be reduced by "errorproofing"—building processes so that the error either cannot happen or is unlikely to happen.

Principles of Errorproofing. Research has indicated that there are a number of different classifications of errorproofing methods, and these are spelled out below.

Elimination: This consists of changing the technology to eliminate operations that are error-prone. For example, in some materials handling operations, the worker should insert a protective pad between the lifting wire and the product so that the wire will not damage the product. Elimination could consist of using nylon bands to do the lifting.

Replacement: This method retains the error-prone operation but replaces the human worker with a nonhuman operator. For example, a human worker may install the wrong component into an assembly. A properly designed robot avoids such errors. Nonhuman processes, so long as they are properly maintained, do not have lapses in attention, do not become weary, do not lose their memory, and so on.

Facilitation: Under this method, the error-prone operation is retained, and so is the human worker. However, the human worker is provided with a means to reduce any tendency toward errors. Color coding of parts is an example.

Detection: This method does nothing to prevent the human error from happening. Instead, it aims to find the error at the earliest opportunity so as to minimize the damage done. A widespread example is automated testing between steps in a process.

Mitigation: Here again, the method does nothing to prevent the human error from happening. However, means are provided to avoid serious damage done. A common example is providing a fuse to avoid damage to electrical equipment.

Optimize Process Features and Goals. After the planners have designed for critical factors and made modifications to the plan for ways of reducing human error, the next activity is to optimize first the subprocesses and then the overall process design. In step 4, develop product, the concept of optimization was introduced. The same activities performed for optimizing product features and product feature goals also apply to process planning. Optimization applies to both the design of the overall process and the design of individual subprocesses.

Establish Process Capability. Before a process begins operation, it must be demonstrated to be capable of meeting its quality goals. The concepts and methods for establishing process capability are discussed in detail in Section 22, under Process Capability. Any planning project must measure the capability of its process with respect to the key quality goals. Failure to achieve process capability should be followed by systematic diagnosis of the root causes of the failure and improvement of the process to eliminate those root causes before the process becomes operational.

Reduction in Cycle Time. Process capability relates to the effectiveness of the process in meeting customer needs. One special class of needs may relate to subprocess cycle time—the total time elapsed from the beginning of a process to the end. Reducing cycle time has almost become an obsession for many organizations. Pressures from customers, increasing costs, and competitive forces are driving companies to discover faster ways of performing their processes. Often these targeted processes include launching new products, providing service to customers, recruiting new employees, responding to customer complaints, and so on. For existing processes, designers follow the well-known quality-improvement process to reduce cycle time. Diagnosis identifies causes for excessive time consumption. Specific remedies are then developed to alleviate these causes. (See Section 5, The Quality Improvement Process.)

Set and Publish Final Process Features and Goals. After the planning team has established the flow of the process, identified initial process features and goals, designed for critical processes and human error, optimized process features and goals, and established process capabilities, it is ready to define all the detailed process features and goals to be included in the final design. This is also the stage where the results of process development are officially transmitted to other functions through various forms of documentation. These include the specifications for the product features and product feature goals as well as the spreadsheets and other supporting documents. All this is supplemented by instructions, both oral and written.

Filling out the process design spreadsheet is an ongoing process throughout process development. The spreadsheet should have been continually updated to reflect design revisions from such activities as reviewing alternative options, designing for critical factors and human error, optimizing, testing process capability, and so on. After making the last revision to the process design spreadsheet, it should be checked once more to verify the following:

- That each product feature has one or more process features with strong or very strong relation. This will ensure the effective delivery of the product feature without significant defects. Each product feature goal will be met if each process goal is met.
- That each process feature is important to the delivery of one or more product features. Process features with no strong relationship to other product features are unnecessary and should be discarded.

The completed process design spreadsheet and detailed flow diagrams are the common information needed by managers, supervisors, and workers throughout the process. In addition, the planning team must ensure that the following are also specified for each task within the process:

- Who is responsible for doing it

- How the task is to be competed
- Its inputs
- Its outputs
- Problems that can arise during operations and how to deal with them
- Specification of equipment and materials to be used
- Information required by the task
- Information generated by the task
- Training, standard operating procedures, job aids that are needed

STEP 6: DEVELOP PROCESS CONTROLS/ TRANSFER TO OPERATIONS

In this step, planners develop controls for the processes, arrange to transfer the entire product plan to operational forces, and validate the implementation of the transfer. There are seven major activities in this step.

- Identify controls needed.
- Design feedback loop.
- Optimize self-control and self-inspection.
- Establish audit.
- Demonstrate process capability and controllability.
- Plan for transfer to operations.
- Implement plan and validate transfer.

Once planning is complete, these plans are placed in the hands of the operating departments. It then becomes the responsibility of the operational personnel to manufacture the goods or deliver the service and to ensure that quality goals are met precisely and accurately. They do this through a planned system of quality control. Control is largely directed toward continuously meeting goals and preventing adverse changes from affecting the quality of the product. Another way of saying this is that no matter what takes place during production (change or loss of personnel, equipment or electrical failure, changes in suppliers, etc.), workers will be able to adjust or adapt the process to these changes or variations to ensure that quality goals can be achieved.

Identify Controls Needed. Process control consists of three basic activities:

- Evaluate the actual performance of the process.
- Compare actual performance with the goals.
- Take action on the difference.

Detailed discussions of these activities in the context of the feedback loop are contained in Section 4, The Quality Control Process.

Control begins with choosing quality goals. Each quality goal becomes the target at which the team directs its efforts. All control is centered around specific things to be controlled. We will call these things “control subjects.” Each control subject is the focal point of a feedback loop. Control subjects are a mixture of

Product features: Some control is carried out by evaluating features of the product itself (e.g., the invoice, the gear wheel, the research report, etc.) Product controls are associated with the decision: Does this product conform to specifications or goals? Inspection is the major activity for answering this question. This inspection is usually performed at points where the inspection results make it possible to determine where breakdowns may have occurred in the production process.

Process features: Much control consists of evaluating those process features which most directly affect the product features, e.g., the state of the toner cartridge in the printer, the temperature of the furnace for smelting iron, or the validity of the formulas used in the researcher's report. Some features become candidates for control subjects as a means of avoiding or reducing failures. These control subjects typically are chosen from previously identified critical factors or from conducting FMEA, FTA, and criticality analysis. Process controls are associated with the decision: Should the process run or stop?

Side-effect features: These features do not affect the product, but they may create troublesome side effects, such as irritations to employees, offense to the neighborhood, threats to the environment, and so on.

These three types of control subjects may be found at several different stages of the process:

- Setup/startup
- During operations, including

  Running control
  Product control
  Supporting operations control
  Facility and equipment control

Design Feedback Loop. Once the control subjects are selected, it is time to design the remainder of the feedback loop by

- Setting the standards for control—i.e., the levels at which the process is out of control and the tools, such as control charts, that will be used to make the determination
- Deciding what action is needed when those standards are not met, e.g., troubleshooting.
- Designating who will take those actions

A detailed process flow diagram should be used to identify and document the points at which control measurements and actions will be taken. Then each control point should be documented on a control spreadsheet similar to Figure 3.15.

Optimize Self-Control and Self-Inspection. As discussed in more detail in Section 22, Operations, self-control takes place when workers know what they are supposed to do. Goals and targets are clearly spelled out and visible.

- Workers know what they are doing. Their output is measured, and they receive immediate feedback on their performance.
- Workers have the ability and the means to regulate the outcomes of the process. They need a capable process along with the tools, training, and authority to regulate it.

In addition to providing the optimal conditions for process operation and control, establishing self-control has a significant, positive impact on the working environment and the individuals in it. Whenever possible, the design of the quality control system should stress self-control by the operating forces. Such a design provides the shortest feedback loop but also requires the designers to ensure that the process capability is adequate to meet the product quality goals.

Once self-control is established, self-inspection should be developed. Self-inspection permits the worker to check that the product adheres to quality standards before it is passed on to the next

	PROCESS CONTROLS						
PROCESS FEATURE	CONTROL SUBJECT	SENSOR	GOAL	MEASUREMENT FREQUENCY	SAMPLE SIZE	CRITERION	RESPONSIBILITY
PROCESS FEATURE 1							
PROCESS FEATURE 2							
⋮							
WAVE SOLDER	SOLDER TEMPERATURE	THERMOCOUPLE	505°F	CONTINUOUS	N/A	⩾510°F, DECREASE HEAT; 500°F, INCREASE HEAT	OPERATOR
	CONVEYOR SPEED	FT/MIN METER	4.5 FT/MIN	1/HOUR	N/A	⩾5 FT/MIN, REDUCE SPEED; ⩽4 FT/MIN, INCREASE SPEED	OPERATOR
	ALLOY PURITY	LAB. CHEM. ANALYSIS	1.5% MAX TOTAL CONTAMINANTS	1/MONTH	15 GRAMS	⩾1.5%, DRAIN BATH, REPLACE SOLDER	PROCESS ENGINEER

FIGURE 3.15 Control spreadsheet. [*From Juran, J. M. (1988), Quality Control Handbook, 4th ed. McGraw-Hill, New York, 6.9.*]

station in the production cycle. Production and front-line workers are made to feel more responsible for the quality of their work. Feedback on performance is immediate, thereby facilitating process adjustments. Traditional inspection also has the psychological disadvantage of using an "outsider" to report the defects to the worker. The costs of a separate inspection department can be reduced.

However, some prerequisite criteria must first be established:

Quality is number one: Quality must undoubtedly be made the highest priority. If this is not clear, the workers succumb to schedule and cost pressures and classify as acceptable products that should be rejected.

Mutual confidence: Managers must trust the workers enough to be willing to delegate the responsibility and the authority to carry out the work. Workers must also have enough confidence in managers to be willing to accept this responsibility and authority.

Training: Workers should be trained to make the product conformance decisions and should also be tested to ensure that they make good decisions.

Specifications must be unequivocally clear.

The quality audit and audit of control systems are treated elsewhere in detail—see, for example, Section 22, under Audit of Operations Quality. While the audit of a control system is a function independent of the planning team, the planning team does have the responsibility for ensuring that adequate documentation is available to make an effective audit possible and that there are provisions of resources and time for conducting the audit on an ongoing basis.

Demonstrate Process Capability and Controllability. While process capability must be addressed during the design of the process, it is during implementation that initial findings of process capability and controllability must be verified.

Plan for Transfer to Operations. In many organizations, receipt of the process by operations is structured and formalized. An information package is prepared consisting of certain standardized essentials: goals to be met, facilities to be used, procedures to be followed, instructions, cautions, and so on. There are also supplements unique to the project. In addition, provision is made for briefing and training the operating forces in such areas as maintenance, dealing with crisis, and so on. The package is accompanied by a formal document of transfer of responsibility. In some organizations, this transfer takes place in a near-ceremonial atmosphere.

The structured approach has value. It tends to evolve checklists and countdowns that help ensure that the transfer is orderly and complete. If the organization already has a structure for transfer, project information may be adapted to conform with established practice. If the company has a loose structure or none at all, the following material will aid in planning the transfer of the project.

Regardless of whether the organization has a structure or not, the team should not let go of the responsibility of the project until it has been validated that the transfer has taken place and everyone affected has all the information, processes, and procedures needed to produce the final product.

Transfer of Know-How. During process design, the planners acquire a great deal of know-how about the process. The operating personnel could benefit from this know-how if it were transferred. There are various ways of making this transfer, and most effective transfers make use of several complementary channels of communication, including

Process specifications

Briefings

On-the-job training

Formal training courses

Prior participation

Audit Plan for the Transfer. As part of the plan for formal transfer, a separate audit plan should also be developed as a vehicle for validating the transfer of the plan. This kind of audit is different from the control audits described previously. The purpose of this audit is to evaluate how successful the transfer was. For the audit to have real meaning, specific goals should be established during the planning phase of the transfer. Generally, these goals relate to the quality goals established during the development of the product, product features, and process features. The team may decide to add other goals inherent to the transfer or to modify newly planned quality goals during the first series of operations. For example, during the first trial runs for producing the product, total cycle time may exceed expected goals by 15 percent. This modification takes into account that workers may need time to adjust to the plan. As they become more skilled, gain experience with the process, and get more comfortable with their new set of responsibilities, cycle time will move closer to targeted quality goals.

The audit plan for the transfer should include the following:

- Goals to meet
- How meeting the goals will be measured
- The time phasing for goals, measurement, and analysis
- Who will audit
- What reports will be generated
- Who will have responsibility for corrective action for failure to meet specific goals

Implement Plan and Validate Transfer. The final activity of the quality planning process is to implement the plan and validate that the transfer has occurred. A great deal of time and effort has gone into creating the product plan, and validating that it all works is well worth the effort.

REFERENCES

Designs for World Class Quality (1995). Juran Institute, Wilton, CT.

Juran, Joseph M. (1992). *Quality by Design.* Free Press, New York.

Parasuraman, A., Zeithami, Valarie A., and Berry, Leonard L. (1985). "A Conceptual Model for Service Quality and Its Implications for Further Research." *Journal of Marketing,* Fall, pp. 41–50.

Veraldi, L. C. (1985). "The Team Taurus Story." MIT Conference paper, Chicago, Aug. 22. Center for Advanced Engineering Study, MIT, Cambridge, MA.