

Customer Collaboration with ISO 16355 (Quality of New Product Development)

Glenn Mazur, Executive Director
International Council for QFD
glenn@mazur.net

Key words: ISO 16355, Quality Function Deployment (QFD), Voice of Customer, New Product Development

Paper category: Customer collaboration

What is QFD?

Quality Function Deployment is methodology designed to improve customer satisfaction by increasing the quality of new products and services. Unlike traditional quality methods that focus on solving existing, known problems to achieve “zero defect,” QFD is driven by the voice of the customer to explore high priority spoken and unspoken needs that must be met for a new product or service to be accepted. To achieve this first time quality, developers must know what problems the customer has, how important those problems are to helping the customer do their job or live their life better, and what level of improvement is necessary for the customer to accept it in place of their current product. Thus, QFD is highly dependent on collaboration with the customer and their business or life, the industry of the product or service, and what competitive alternatives the customer has access to. This paper will include how these same methods are being used to write this QFD standard itself.

Brief History of QFD

QFD was developed in Japan in the 1960s¹ (during its period of modernizing traditional approaches to quality management) to assure that not only was negative quality (customer dissatisfaction) addressed in the design and development of new products and services, but that positive quality (customer satisfaction) become the hallmark of competitiveness. In other words, a lack of dissatisfaction does not guarantee satisfaction; i.e. nothing ≠ anything right. The concept was extraordinary at the time. Traditional approaches to product design were typically driven by technical advancements that often failed in usability or made downstream manufacturability or service delivery a nightmare. The QFD approach recommends that:

- Assuring product quality requires a multi-functional team approach. Quality professionals typically engage too late in the process to truly affect customer satisfaction and value.
- For customer-focused design, it is critical to involve the users, buyers, and other stakeholders who can make or influence a purchase decision. QFD recommends that marketing play a leading role in acquiring and analyzing the voice of the customer (VOC) to quantify what matters most.
- Different customers have different needs with different priorities. It is important to get an accurate priority from them before detailed development and implementation begin. This will improve quality, acceptance, and timing, and lower costs due to waste and rework.
- Customer needs are transferred into product requirements and then tracked as they move through the commercialization, support, and even retirement process in order to assure that customer satisfaction is maintained.

QFD helped many Japanese companies, particularly auto makers, achieve stunning customer satisfaction success and increased market share, and thus caught the eye of U.S. quality experts after an article was published in *Quality Progress*² in 1983. The automotive supply industry began study missions to Japan to learn more.

The early approaches to QFD began with corporate quality activities and initially focused on the interface between manufacturing engineering and production. However, over time it became apparent that customer satisfaction could begin further upstream in the development process. QFD has since evolved to include design, marketing, R&D, strategic planning, product management, project management, and other departments in the product realization process. In its current best practice, collaboration with customers and users is essential to deep understanding of spoken and unspoken customer needs and assuring their quality throughout the product's development, commercialization, and even retirement.

In 2009, the Japan Standards Organization (JSA) initiated a proposal to write a standard for QFD under the auspices of the Technical Committee 69 for Statistical Methods Subcommittee 8 for New Product Development. Identified as ISO 16355, it is currently in draft development to address the quality issues associated with new product development. The standard has eight parts to address the identification of customers and stakeholders, acquire their "voices" (VOC and VOS), analyze and prioritize the voices, create innovative solutions, and assure their robustness and design quality throughout the development, implementation, commercialization, and retirement phases of product use. The standard is applied to physical products (assembly and process), service, software, and internal business processes. This paper will present the current state of development of the committee draft of Part 1 of the standard and applicable tools and methods, with examples.

Part 1. General principles and perspectives of the QFD method

Part 2. Acquisition of VOC/VOS – non-quantitative approaches

Part 3. Acquisition of VOC/VOS – quantitative approaches

Part 4. Analysis of non-quantitative and quantitative VOC/VOS

Part 5. Strategy and Translation of VOC into engineering solutions and cost planning

Part 6. Optimization – robust parameter design

Part 7. Optimization – tolerance design

Part 8. Guidelines for commercialization and life cycle

Types of QFD Projects

QFD can be applied to both existing and new markets as well as to both existing and new technologies. QFD projects can be driven by external sources such as market/customer demands, competitive threats or opportunities, technology change, regulatory changes, etc., and/or internal sources such as cost reduction, manufacturing opportunities, new materials, knowledge management, etc. QFD projects can focus on hardware, service, software, process, systems, interface, or some combination. QFD projects can be applied at any level: the societal, environmental, end product, system, subsystem, component, production, material, manufacturing process, service process, support, or supplier level. Projects may progress upstream from micro detail to macro systems, downstream from macro to micro, or expand outward from a midstream level.

QFD Teams

The basic concept of QFD is to ensure quality throughout each stage of the product development process, while keeping the focus on customer satisfaction. Team membership should consist of a core team and invited subject matter experts. Core team members should represent business functions needed for the project. They should extend end-to-end across the development and commercialization process to prevent gaps from diminishing customer satisfaction. Subject matter experts may be invited as the project requirements flow down to different departments in the organization whose specialty is required to develop and review requirements. Common experts include marketing (consumer insights, consumer experience, statisticians, conjoint analysis, survey design, etc.), engineering (electronics, components, value engineers, software, materials, packaging, etc.), manufacturing (stamping, forming, equipment, supply, industrial, etc.), quality (six sigma, statisticians, inspection, gage, design of experiments, supplier quality, etc.), services (technical writers, technical support, phone centers, etc.) and others.

Definition of a Customer/Stakeholder

A product provides benefit to one or more “customers.” There may also be a chain of involved customers/stakeholders including constituents (of a social service), end users and consumers, intermediate users such as dealers, installers, operators, maintenance, etc., and internal customers such as human resources, manufacturing, etc. who reflect the underlying customer value network of delivering of the product to the user. The relationships among customers should be clarified. When many customers exist, they may be prioritized in order to focus resources first on high priority customers.

Voice of Customer and Customer Needs

VOC is raw, unprocessed information from the customer. It often includes complaints, needs, functional requirements, performance specifications and targets, solutions, components, materials, activities, information, etc. To be most useful, these must be sorted, analyzed, structured, quantified, and prioritized by key customers. Sources of VOC include customer interviews, focus groups, observational studies, surveys, field reports, warranty claims, customer support (in-person, phone, email, FAQ queries), and social media (text, video, sound), among others.

Customer needs are defined in QFD as being benefits the customer receives when their problems are solved, their opportunities are enabled, or their image (to self and to others) is enhanced, *independent* of the product or solution. The goal is to derive true customer needs so from the voice of the customer, customer needs have to be identified and separated from solutions specified by the customer or the product development team. Clear separation of needs and solutions leads to more flexibility and innovation in finding appropriate solutions for all stakeholders. Translating the raw VOC into customer needs can be done in a modern QFD tool, the customer voice table. The table consists of a “customer” side on the left and a product side on the right. The left side identifies the VOC (labeled in the example in Table 1) as “customer problem,” since many customer feedbacks come that way. It could also include customer supplied specifications, observations, suggestions, and others. These various VOCs are then positioned in

the right side of the table in columns that describe such product attributes as design ideas. Finally, each of these VOC is translated into a customer need statement at the center of the table. The example in Table 1 came from potential users of the standard.

Table 1 Translating VOC into customer needs with customer voice table³

Segment	VOC (Standards User)	Customer Need	Design Ideas
Aerospace Engineer	where to look up standard, how to find	Easy to find standard when I need it.	Put ISO links on ICQFD member websites?
	differs from our std	Easy to know how standard differs from our internal standards.	
	simple enough for average person to understand	Easy for non-QFD specialist to understand.	
	too loosey-goosey - is it worth the trouble	Standard is useful to my work.	Sufficient detail. Role specific (marketing, design, engineering, manufacturing, quality, supply chain, etc.
	morphs over time to cover new req't - are we using current version? User wants to stay up to date with standard, offer suggestions on how to improve or make more relevant.	I am always working from the current version. I know when next version will be released so I can plan for it. Standard is useful to my future work.	Ongoing VOC feedback gathering.
	have multiple implementation levels within the standard. Common level, plus special areas with more meat.	Standard is easy for beginners to utilize. Standard is useful to my work.	Multiple implementation levels.
	make sure your customer and vendors buy into the standard - cost/benefit ratio	Benefits of following standard are easy to explain to my customers. Easy for my vendors to follow the standard. Easy to follow standard.	
	easily accommodates changes in my business as technology changes.	Standard is easy to adapt to changes in my business.	Publish case studies?
	make something people want to use. must be easy to use, especially if voluntary.	Standard is useful to my work. Easy to follow standard.	
	must be on a website. Best if no charge because of the effort to rationalize to my boss or company the need to pay for the documentation.	Easy to find standard when I need it. Benefits of following standard are easy to explain to my management.	Standard published on website.

Customer Needs Prioritization

In order to focus where maximum benefit to customers/stakeholders can be provided with minimal effort by the QFD team, prioritization of the customer needs is recommended. Prioritization should be done by the group that “owns” the information; customer needs should be prioritized by the customer. These priorities should be as accurate as possible as they serve later QFD activities related to cost and resource allocation. The mathematical limitations of different numerical scales should be respected. Early QFD practitioners used “abacus” math on ordinal scales but now with computers, the more precise ratio scale math is recommended. The analytic hierarchy process (AHP)⁴ is often used to calculate ratio scale priorities.

Prioritization in multi-criteria decision making was advanced by the research of Dr. Thomas Saaty in the 1970s at the U.S. Department of Defense and later at the Wharton School of Business at the University of Pennsylvania. Saaty found that decision makers facing a multitude of elements in a complex situation innately organized them into groups sharing common properties, and then organized those groups into higher level groups, and so on until a top element or goal was identified. This is called a hierarchy and when making informed judgments to estimate importance, preference, or likelihood, both tangible and intangible factors must be included and measured. A properly organized and prioritized hierarchy can tell us if we have sufficient needs to satisfy the customers. In other words, do we have enough needs that the customer would be satisfied with the product, if we delivered them? Modern QFD uses Saaty’s analytic hierarchy process (AHP) technique to manage customer needs prioritization in a manner that captures the intuitive understanding of the customers and also yields mathematically stable results expressed in a numerical, ratio scale. A numerical, ratio scale is preferred for the following reasons:

- Numerical priorities can be applied to later analyses to derive downstream priorities. This will be important in guiding the developers and implementers of new solutions.

- Ratio scale priorities show precisely how much more important one need is than another. Ordinal scales only indicate rank order, but not the magnitude of importance or the interval between the levels.
- Numerical scales can be tested for judgment inconsistency, sensitivity, and other useful properties. As AHP does not require rational responses, an inconsistency check will quantify and identify judgment inconsistencies by looking for instances of $a > b$, $b > c$, but $c > a$.

Transforming Prioritized Customer Needs into Prioritized Product Functional Requirements

Once prioritized, high value needs can be transformed into product requirements. In classical QFD, this was done using a house of quality that lists the customer needs in the rows of a matrix and the functional requirements in the columns, and weights the strength of the relationship between them. Weights are then cross-tabulated to calculate requirement weights. An example from the development of the ISO 16355 standard is shown in Table 2.

Table 2 House of quality for development of ISO 16355

Functional Requirements 品質要素	Priority 要求品質重要度	Efficiency	Reusability	Defensibility	Traceability
		効率性	再利用可能性	防御可能性	追跡可能性
Standard helps my products get certified. 製品の規制要件を満たす	0.134	0.015	0.000	0.046	0.032
Standard helps my processes get certified. 工程の規制要件を満たす	0.055	0.006	0.000	0.013	0.013
Standard helps me meet regulatory requirements. 製品が認証を受ける	0.103	0.000	0.012	0.051	0.051
Supports requirements tracability. 要求のトレーサビリティをサポートする	0.029	0.002	0.007	0.000	0.029
Absolute Weight 絶対ウエート		0.023	0.018	0.110	0.125
Functional Requirement Weight 品質要素ウエート		0.083	0.067	0.399	0.452
FR Rank		3	4	2	1

The classical house of quality offers a comprehensive mapping of customer needs into the functional requirements in order to define the solution. The customer priorities transfer to functional requirement priorities and indicate which will be more critical than others due to their strong contribution or relationship. Since the final functional requirement priorities can only be calculated after the matrix is filled in completely, the exercise can be very time consuming for large matrices. In the auto industry, for example, some matrices grew to nearly 1000 rows by 1000 columns that would require 1,000,000 relationships to be examined carefully, a task that took some teams two to three years to complete. In many businesses, such as technology where product

development is measured in weeks rather than years, this became an insurmountable barrier to the use of QFD.

In the late 1990s, Dr. Akao sensing the problem, instructed the QFD Institute to modernize the QFD process to accommodate this need for speed. The result was a matrix-free alternative that used customer need priorities to segregate the critical few from the trivial many and then deploy only the critical ones. With the improved accuracy of AHP over abacus math, practitioners gained confidence that they could cherry-pick the few functional requirements as well as key quality assurance items in subsequent QFD matrices, without actually having to do the matrices at all. By tabularizing the information, all the key items in all the subsequent matrices could be displayed in a single chart, call the maximum value table. An example from a U.S. children’s hospital is shown in Table 3. The model for the maximum value table is based on a fish-bone diagram with the “head” representing a desirable effect (customer need) and the “bones” and sub-bones representing the design elements that cause the need to be fulfilled. In this example, the customer need of patients and parents to participate in their care is fulfilled by the clinic designing in the capability to help parents set health goals for their children. The design should include:

1. Various forms of communication between the clinic and family such as email, telephone, sign language, etc.
2. A way to enter specific goals into the electronic medical records so they can be shared with other medical staff caring for the child
3. Ability to speak to the parents and child in their native language.

Table 3 Maximum value table⁵

Customer			Analysis	Design	
			Functional Requirements	Design Requirements	
task	problems	needs	characteristics & capabilities	solution technology	
Pre clinic	Parents may or may not provide goals for their child	Patients and parents need to participate in their care	Capability to help parents to set goals for their child. Capability to help parents communicate goals to provider prior to clinic.	Selectable modality of communication: email, written, verbal; signing, and on line. Goals should be entered electronically prior to the clinic visit. Ability to communicate goals in family's native language.	
			Capability to help parents understand care requirements for their child, i.e. how to feed, how to give meds, monitoring of equipment, troubleshooting equipment.	Telemetry for equipment to communicate directly to hospital.	
			Capability to help parents	Follow up nurse	

These capabilities could then be developed into a software application that to be used by both parents and the clinic staff on multiple platforms such as computers, tablets, smart phones, and others yet to be invented. The result was that the app developers could begin their work as an agile SCRUM team in a short-term sprint and get the product benefiting the families and staff quickly. Another benefit of the maximum value table is that it can later be expanded into a series of classical QFD houses should it be necessary. So, the modern QFD tools can be upgraded into comprehensive QFD without wasted time or effort, and the team can begin earlier on the most critical development challenges.

Customer Support

Collaboration with customers does not end with the release of the product. Additional technical, after-sales, and other support activities may be needed. Other downstream customers such as maintenance, repair (including parts, service training, etc.), recycling, and others are part of the customer relationship. Information related to design changes, new features, consumables, setup, and other concerns that customers and users could encounter should be created. Support databases, support staff, support levels (such as gold, silver, bronze) should be created in line with customer expectations and needs.

Customer Satisfaction Measurement

Customer feedback related to new features, new complaints or concerns, competitive offerings, etc. should be gathered and fed to improvement teams as well as to next generation design efforts. Sampling surveys should be done to periodically test markets for shifts in customer priorities, competitive threats, and responses to promotions.

ISO 16355 Parts 2-8

Part 1 introduces the QFD concept for new product development quality and briefly describes possible steps, methods, and tools. The remaining parts of the standard will provide more detail. Parts 2-5 will offer guidance on quantitative and non-quantitative collaboration with customers, while parts 6-7 will focus more on the use of statistical methods to optimize the design. Part 8 will report on downstream deployments of the design through the build, commercialization, and retirement of the product from the field.

Conclusion

The role played by the quality function of an organization is growing to bring the benefits of statistical methods, measurement, and quality thinking to other departments and activities. Successful enterprises need improvement in all operations, not just production. As developed economies move to non-manufacturing work such as sales/marketing, R&D, financial services, healthcare and social services, etc. it is necessary that the benefits that quality practices have brought to the manufacturing world be extended to these activities, as well. There is no room for inefficiencies and waste in any part of a modern organization. ISO 16355 will show that statistical methods that have improved the quality of current business operations can also help new product, service, and software developers. Our customers deserve better, our staffs deserve better, and our society deserves better.

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