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Applications of statistical and related methods to new technology and product development process —

Part 5: Solution strategy

Application des méthodes statistiques et des méthodes liées aux nouvelles technologies et de développement de produit — Partie 5: Stratégie de solution

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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A list of all parts in the ISO 16355 series can be found on the ISO website.

Introduction

Quality Function Deployment (QFD) is a method to ensure customer or stakeholder satisfaction and value with new and existing products by designing in, from different levels and different perspectives, the requirements that are most important to the customer or stakeholder. These requirements can be well understood through the use of quantitative and non-quantitative tools and methods to improve confidence of the design and development phases that they are working on the right things. In addition to satisfaction with the product, QFD improves the process by which new products are developed.

Reported results of using QFD include improved customer satisfaction with products at time of launch, improved cross-functional communication, systematic and traceable design decisions, efficient use of resources, reduced rework, reduced time-to-market, lower life cycle cost, improved reputation of the organization among its customers or stakeholders.

This document demonstrates the dynamic nature of a customer-driven approach. Since its inception in 1966, QFD has broadened and deepened its methods and tools to respond to the changing business conditions of QFD users, their management, their customers, and their products. Those who have used older QFD models can find these improvements make QFD easier and faster to use. The methods and tools shown and referenced in the standard represent decades of improvements to QFD; the list is neither exhaustive nor exclusive. Users can consider the applicable methods and tools as suggestions, not requirements.

This document is descriptive and discusses current best practice, it is not prescriptive by requiring specific tools and methods.

Applications of statistical and related methods to new technology and product development process —

Part 5:
Solution strategy

1 Scope

This document describes the process of developing a solution strategy for new products. Since organizations can address their new product development process by a customer-driven or a technology-driven set of solutions, this document explains both alternatives. It provides recommendations on the use of the applicable tools and methods, offering guidance on translating the voice of the customer (VOC) and voice of the stakeholder (VOS) into product, service, information, and process attributes, transferring the priorities of the customer and stakeholder needs into priorities for these attributes, and then developing technology, cost, and reliability plans for attributes.

Users of this document include all organization functions necessary to ensure customer satisfaction, including business planning, marketing, sales, research and development (R&D), engineering, information technology (IT), manufacturing, procurement, quality, production, service, packaging and logistics, support, testing, regulatory, and other phases in hardware, software, service, and system organizations.

2 Normative references

The following documents are referred to in text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16355-1:2015, *Applications of statistical and related methods to new technology and product development process*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 16355-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Management summary

4.1 Basic concepts of QFD

The basic concepts of QFD are referenced in ISO 16355-1:2015, Clause 4.

4.2 Evolving classical QFD into modern QFD

4.2.1 General

QFD was first systematized in Japan in 1966 for applications in the automotive industry.[3] As new industries and applications emerged, the method, tools, and flow of information evolved to address the unique factors of each company. In recent years, the methods in 4.2.2 to 4.2.6 are most commonly used.

4.2.2 Classical QFD

Automotive component suppliers created a simplified flow that translated original equipment manufacturer (OEM) specifications into component specifications and process requirements using a series of four matrices, as follows:

a) customer requirements into product requirements;

b) product requirements into component requirements;

c) component requirements into manufacturing requirements;

d) manufacturing requirements into process requirements.

NOTE 1 Classical QFD is also called 4-phase QFD because of the four matrices used.[16] These four matrices are highlighted in yellow in Figure 3.

NOTE 2 The 4-phase QFD charts in this document and ISO/TR 16355-8 use improved mathematics and tighter definitions to guide the user, resulting in faster implementation and more confident results.

4.2.3 Comprehensive QFD

The 4-phase QFD was readily adopted around the world for its simplicity and easy implementation. As QFD gained popularity, other industries, including finished goods, services, software and information systems, and processes struggled to make it fit their products and business models. This led adding more tools and flows to create a more comprehensive approach. Comprehensive QFD ensures the quality of new products by including market research to understand customer needs as referred to in ISO 16355-2 and ISO 16355-4, translating customer needs into design quality targets, and then deploying to innovation, cost, and reliability phases. It enables greater flexibility in application to a broad variety of industries including aerospace, architecture, construction, electronics, materials processing, services, and software.[1][24] The many tools and information flows enable the user to select which ones are applicable to their project. In Figure 3, the vertical deployments are quality, technology, cost, and reliability. The horizontal deployments are customer, product, function, components, and build. The purpose of this document and ISO/TR 16355-8 is to guide users in harnessing the full capabilities of comprehensive QFD.

4.2.3.1 Quality deployment

10.4.2 describes how product-independent customer needs are translated into functional requirements of the product, service, process, or information technology. Additionally, customer priorities and satisfaction targets are transferred into functional requirement priorities and performance targets, independent of the enabling technology. This technology independence allows for greater freedom of design in technology deployment. Functional requirements are then deployed to components, processes, and quality assurance.

4.2.3.2 Technology deployment

Either in response to unachievable product function and performance, or in engineering-driven innovation, technology deployment matches systems and subsystems to assess how well they achieve the prioritized functions and performance targets. This can trigger additional innovation efforts, refinement of technology concepts regarding user experience and interface, redirection of technologies

to more appropriate markets and customers, and establish criteria for technology assessment and selection, including costs. This is detailed in 10.4.3.

4.2.3.3 Cost deployment

As technologies are explored, the costs to develop and produce them must align with market price and business financial requirements such as revenues and profits. Selling price targets drive product cost targets which flow down to system, subsystem, component, and build cost targets. This flow down is managed through the tables and matrices in cost deployment. Since costs are absolute and not relative, the calculations in cost deployment matrices are more precise and are detailed in 10.4.4.

4.2.3.4 Reliability deployment

New technology increases risks related to many unknowns in actual customer usage, interactions with other systems provided by other suppliers, new materials, new software, and others. Risk of unknown failures can be, to some degree, forecasted based on known failures. Reliability deployment is detailed in 10.4.5.

NOTE 1 The comprehensive QFD charts in this document use improved mathematics and tighter definitions to guide the user, resulting in faster implementation and more confident results.

NOTE 2 Additional tools and methods have been added to comprehensive QFD such as strategic planning and market segmentation (referred to in ISO 16355-2), voice of customer translation into customer needs and improved mathematics (referred to in ISO 16355-4), and innovation and costing methods referred to in this document in 10.4.3.4 and 10.4.4, respectively.

NOTE 3 According to the scope of the project, a subset of these deployments and their associated tools can be required. Management awareness that such deployments exist helps improve their directives to product development teams, monitor their process, in order to increase their confidence in the results.

4.2.4 Matrix of matrices

A version of the comprehensive QFD models was developed to make the matrices easier to follow thought a systematic re-drawing of the information flows. It is called the matrix of matrices[28] and displays the charts independent of each other. It is referenced in the standard when applicable.

4.2.5 Modern Blitz QFD® 1)

As modern businesses work to improve efficiency in a highly competitive global marketplace, the need for speed in new product development has emerged as an important constraint on QFD. The resources and time required for the classical and comprehensive approaches is not always feasible, and so a faster approach was developed by the U.S. QFD Institute called Blitz QFD® as shown in Figure 2. The idea is to get the benefits of comprehensive QFD more quickly by focusing on only a small number of the highest priority customer needs. The emphasis on high priority customer needs requires additional analyses to ensure greater confidence in the prioritization process. Identifying high priority customers, semantic analysis, and situation analysis is explained in ISO 16355-2. Identifying high priority customer needs is explained in ISO 16355-4. Detailed design work is explained here in 9.2.

4.2.6 German QFD Institute model

This model includes several of the tools for market research, innovation, cost reduction, and reliability in the updated comprehensive QFD added to the classical 4-phase QFD. Many users find this a middle way through the other models.[19]

1) Blitz QFD® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

5 Integration of QFD and product development methods

5.1 QFD support for product development methods

QFD support for product development methods is referenced in ISO 16355-1:2015, 5.1.

5.2 Flow of solution development with QFD

5.2.1 Organization of the QFD flow

The flow of QFD methods and tools can vary according to the organization and project requirements. Typically, they begin with broad concerns and through prioritization flow down to specifics. Figure 3 shows the flow of product development from quality to technology to cost to reliability deployments.

5.2.2 Flow charts of strategy and translation of VOC into engineering solutions and cost planning

The detailed flow charts are presented in Figure 2 and Figure 3. These flow charts represent how the various tools in this document link together as a standard operating procedure that can be applied to individual projects. Not all tools are required on all projects. Custom tailoring of appropriate tools and sequence are recommended.

6 Types of QFD projects

QFD projects can encompass new developments as well as generational improvements to existing products. The types of QFD projects are referenced in ISO 16355-1:2015, Clause 6 and ISO 16355-4:2017, Clause 6, notes.

NOTE QFD tools and sequence have evolved since the first studies in the 1960s in the automobile parts industry that used simple diagrams and matrices to identify design elements and downstream manufacturing details. When end-user products, non-manufactured products such as service and software, and business processes began using QFD, additional tools were added to address human tasks, information, and other complexities (see Figure 3). In more recent years, organizational resource constraints have led to a quicker approach that addresses both complexity and speed (see Figure 2). It is consistent with quality methods in general and with customer-driven methods like QFD in particular that the methods and tools evolve and adapt to the ever-changing business environment of its practitioners, in order for them to remain viable and practicable. This evolution is demonstrated in the bibliography of case studies.

7 QFD team membership

7.1 QFD uses cross-functional teams

Cross-functional teams are referenced in ISO 16355-1:2015, 7.1.

7.2 Core team membership

Core team membership is referenced in ISO 16355-1:2015, 7.2.

7.3 Subject matter experts

Subject matter experts involvement is referenced in ISO 16355-1:2015, 7.3.

NOTE The matrix relationships and quantifications can be determined by the QFD team with representatives of customer-facing and technology-facing departments, such as marketing and operations or engineering. It is becoming more common with technology products for customers and stakeholders to be invited to participate, often in multiple meetings as the products are iterated. This is called continuous[18][20] or collaborative QFD.[54]

7.4 QFD team leadership

QFD team leaders or moderators can be trained in the QFD tools and methods in order to effective lead the QFD project. Additional tools, as identified in the appendices can be useful. Basic team facilitation and moderation skills are recommended.

NOTE 1 The QFD team leader can take a position of being function-agnostic so as to remain neutral to any business department or activity.

NOTE 2 Team membership and responsibilities can be indicated according to the development process and functional departments and human resources. This can be detailed in a process map, supplier-input-process-output-customer (SIPOC) steps and inputs, or a cause-and-effect L-matrix.

EXAMPLE Table 1 indicates the product development process in the rows and which departments or resources have what level of responsibility to the project.

Table 1 — QFD team responsibility L-matrix

Process \ Resource	Project owner	Finance	Marketing/Sales	R&D	Engineering	Supply chain	Manufacturing/Production	Logistics	Tech support
Strategize	●	◕	◕	◑	◔	·	·	·	·
Fund	◑	●	◔	◑	·	·	·	·	·
Define customer problem	◑	·	●	◕	◔	·	·	·	◔
Define product solution	○	·	◔	◕	◔	·	◑	·	·
Develop	○	·	◔	◑	●	◕	◑	◔	◔
Test	○	·	○	◔	●	◕	◑	·	·
Source/Supply	○	·	·	◔	◕	●			
Build	○	·	·	○	◕	◑	●	·	○
Commercialize	○	◔	◑	·	◔	◑	◕	●	◔
Support	·	·	◔	○	◔	◔	◑	◕	●
Retire	·	·	·	·	·	·	·	◑	●

Key
- ● Primary responsibity
- ◕ Secondary responsibilty
- ◑ Subject matter expert
- ◔ Support resource
- ○ Keep informed

8 Seven management and planning tools

The use and purpose of the seven management and planning tools are referenced in ISO 16355-2:2017, 8.2.

9 Translation of one information set into another

9.1 General

QFD flows information sets through the various development and commercialization functions of the organization and design dimensions. These flows are called deployments and often require the language of one information set to be translated into another information set, or a single information set broken down into more detail. This translation can be visually displayed to check for completeness and accuracy, and can be mathematically quantified for complex information sets. The first transformation

is often from customer needs into product functional requirements, quality characteristics and capabilities, and specification values. There are two approaches to doing this,

a) maximum value table, and

b) L-matrices.

9.2 Maximum value table

9.2.1 General

The maximum value table is used to show everything on the project that is most important to the customers and stakeholders. It identifies where to apply best efforts to the tasks that are essential to delivering value to customers. By doing so, maximum value to customers results from minimum efforts by the QFD team.

9.2.2 Effect-to-cause diagram

Early QFD studies used an effect-to-cause diagram to show the relationship between product attributes and customer needs.[39] Product attributes cause a customer need to be fulfilled. For each customer need, the QFD team can determine what product attributes, from development through commercialization are essential to delivering quality and satisfaction.

NOTE 1 The traditional cause-and-effect diagram (also known as Ishikawa diagram or fishbone diagram) is adapted in QFD to uncover the root causes of success rather than failure. It has two formats: cause-to-effect, which is explained in ISO 16355-4, and effect-to-cause. Note that the arrows point from one effect to many causal factors.

NOTE 2 The customer need is the effect. The names of causal bones and sub-bones depend upon the product. Technical staff with sufficient product knowledge can be invited to the QFD team to help identify them.

NOTE 3 Target values sufficient to meet the customer need can be determined by experimentation and testing as soon as possible.

NOTE 4 Each customer and stakeholder need can have a separate effect-to-cause diagram. Do high priority customer and stakeholder needs first. The analytic hierarchy process (AHP) can be used by customers and stakeholders to prioritize their needs.[48][17]

EXAMPLE Figure 1 is adapted from the first published QFD case study by Bridgestone Tire in 1966. It shows that the desired effect of smooth ride can be positively caused by proper design of the tire characteristics of tire trueness and sidewall strength, proper setting of the moulding process characteristics of pressure, time, and accurate fit of the mould halves, and proper raw material handling storage humidity and rotating the materials so that the oldest polymers are used first.

NOTE 5 The “head” of the fishbone diagram in QFD is oriented on the left side to indicate the flow of information from left-to-right as will be seen in the maximum value table in 9.2.3. This change in orientation better demonstrates the QFD matrix construction as a set of effect-to-cause diagrams with the heads becoming the rows of the matrix and bones becoming the columns.

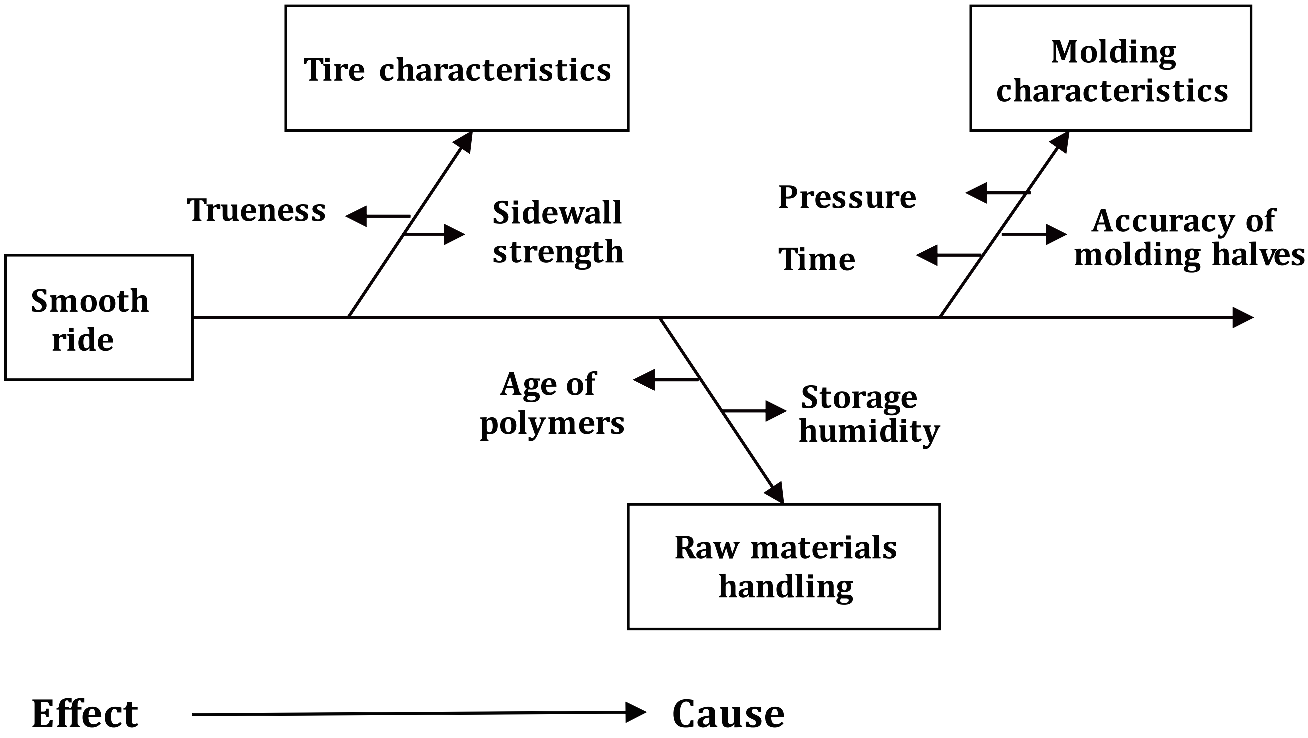

Figure 1 — Effect-to-cause diagram

9.2.3 Steps to make a maximum value table

The effect-to-cause diagram can be presented in a spreadsheet by putting the information into the columns. This is called the maximum value table.

— Enter information regarding the customer such as segment, application and use modes, problem, and other contexts that help the QFD team determine appropriate target values.

— Enter high priority customer and stakeholder needs. The analytic hierarchy process (AHP) can be used by customers and stakeholders to prioritize their needs.[17][48]

NOTE 1 The number of needs to include depend upon the priorities of the needs as well as the project schedule, budget, and available resources. The guideline is to analyse only those needs for which the project can take action. Many projects can have only three to five high-priority needs.

— Identify the necessary design dimensions necessary to address the project. Make these separate column headers.

— For each high priority customer or stakeholder need, enter into the appropriate column any information, target values, tests to be done, and other relevant information as it becomes known. The maximum value table grows as the project progresses end-to-end throughout the development and realization process

— Indicate any special tasks related to this acquiring or acting on this information. Special tasks can be protected from de-scoping by the project manager in cases of budget or schedule conflict, as they are critical to addressing the most important customer or stakeholder needs.

EXAMPLE In Table 2, the highest priority customer need is my employees appreciate the benefits I provide to them.[17] To fulfill this need and ensure that downstream service activities are performed sufficiently, the following must take place:

a) contract should show savings to employee of using insurance;

b) provider network (doctors and hospitals) should show their Blue Cross network is superior to care offered by competing provider networks;

c) to communicate this, the sales broker or representative should explain exactly how the claims mechanism works;

d) system should collect user feedback to ensure it works as promised;

e) system level design should report employee savings and comparisons to street (uninsured) fees.

NOTE 2 Customer needs are transformed into product functional requirements which can include capabilities (technology-independent functions), quality and performance characteristics, and specification targets. In this example, which focuses on communication of information to the employees, only the capabilities of show savings, explain richness of benefits, and show employees how much employer paid are presented.

NOTE 3 The effort to develop and realize a solution strategy for the highest priority needs can consume the available budget, schedule, and human resources. The maximum value table helps ensure the highest value customer and stakeholder needs are addressed first and best. If available resources are consumed, this is possibly all the QFD the team can perform. All other customer and stakeholder needs can then receive standard engineering attention.

NOTE 4 QFD teams needing to address a larger set of customer and stakeholder needs can use an L-matrix to analyse two design dimensions at a time. The maximum value table is useful in determining which design dimensions warrant the L-matrix analysis.

NOTE 5 The maximum value table can be done early in the QFD study to analyse the solution to the most important customer or stakeholder needs. Even if other tools such as L-matrices are employed later, doing the maximum value table first can give the QFD team a head start on the critical needs.

NOTE 6 Maximum value tables from similar products or generations of products can be aggregated into comprehensive QFD L-matrices. This spreads the time and effort over several projects, eventually yielding the benefits of the deeper analysis of comprehensive QFD.

Table 2 — Maximum value table for health insurance company

	Solution						Design	Implementation
Customer need	**Contract**		**Broker/ Representative**	**Operations**		**Feedback**		
	Benefits	**Provider network**		**Member service**	**Claims**			
My employees appreciate the benefits I provide them.	Show savings to employee of using insurance	Explain to employees how Blue Card and BCBSF provider netrowrk is superior	Explain how benefits mechanism works			Assure benefits are working as promised and useful.	Employee savings report information	Expand PHR to include billing comparison to street rate.
	Explain richness of benefits offered through BCBSF	Employee does not have to change "critical" MD (pedia, OBGYN) to conform to plan	Explain to employees industry averages if employer is above average			Employees know they have a conduit for feedback	Provide customer advocate/ombudsman	
	Show employees how much the employer paid for their benefits		Explain network savings				Network savings report info	
							Report to summarize employer payments	
							Validate in PHR that decisions were good decisions (by staying in network/generics/etc.) or alternatives that would offer better outcomes/savings	
							Provide tools to employees that recommend plans based on current provider selections.	
							Provide tools to show employees what their costs would be for various benefit plans based on their experience.	