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

Part 1: General principles and perspectives of quality function deployment (QFD)

Application des méthodes statistiques et des méthodes liées aux nouvelles technologies et de développement de produit —

Partie 1: Principes généraux et perspectives de déploiement de la fonction qualité (QFD)

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 8, *Application of statistical and related methodology for new technology and product development*.

This second edition cancels and replaces the first edition (ISO 16355-1:2015), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— throughout the text, addition of relevant informative references to the other parts in the ISO 16355 series, which are also added to the Bibliography.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Quality function deployment (QFD) is a method to assure 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 are 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 will find these improvements make QFD easier and faster to use. The methods and tools shown and described represent decades of improvements to QFD; the list is neither exhaustive nor exclusive. Users should 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.

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

Part 1: General principles and perspectives of quality function deployment (QFD)

1 Scope

This part of ISO 16355 describes the quality function deployment (QFD) process, its purpose, users, and tools. It does not provide requirements or guidelines for organizations to develop and systematically manage their policies, processes, and procedures in order to achieve specific objectives.

Users of this part of ISO 16355 will include all organization functions necessary to assure 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

There are no normative references cited in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
quality function deployment
QFD
managing of all organizational functions and activities to assure product quality

Note 1 to entry: The organization is responsible for product quality and strives for it via defining, testing, building, commercializing, and supporting the product.

Note 2 to entry: Literal definition is that the "quality function" is "deployed" to all other business functions and departments who play a role in assuring quality and customer satisfaction.

3.2
voice of customer
VOC
communications from the customer

Note 1 to entry: The communications from the customer may be verbal, written, video, audio, animation, or other form and may be descriptive, behavioural, or ethnographic.

Note 2 to entry: *Customer* is defined in ISO 9000:2015, 3.2.4.

3.3
customer need
potential benefit to a customer

Note 1 to entry: The benefit to a customer from having their problem solved, their opportunity enabled, their image (self or to others) enhanced, or being advanced to a more desirable state.

Note 2 to entry: The benefit is positively stated.

Note 3 to entry: The benefit describes a single issue.

Note 4 to entry: The benefit is independent of the product or features.

Note 5 to entry: A need may be explicit or latent.

Note 6 to entry: *Customer* is defined in ISO 9000:2015, 3.2.4.

3.4
functional requirement
characteristic that a product or service is specified to possess

Note 1 to entry: The characteristic could be an inherent performance of the product or an action that the product shall be able to accomplish. The manner in which the product accomplishes the action should not include specific mechanisms or internal procedures is not part of the functional requirement.

Note 2 to entry: *Product* is defined in ISO 9000:2015, 3.7.6.

Note 3 to entry: *Service* is defined in ISO 9000:2015, 3.7.7.

3.5
voice of stakeholder
VOS
communications from the stakeholder

Note 1 to entry: The communications from the stakeholder may be verbal, written, video, audio, animation, or other form and may be descriptive, behavioural, or ethnographic.

Note 2 to entry: *Stakeholder* is defined in ISO 9000:2015, 3.2.3.

3.6
customer gemba
location where true information is found

Note 1 to entry: Gemba is a Japanese word meaning the place where the truth is discovered. In Six Sigma, this usually refers to the shop floor where internal activities take place. In QFD for new product development, the new product does not exist yet, so the gemba changes to where the customer's activities or encounters take place.

Note 2 to entry: There may be no physical location, i.e. for eCommerce or some processes.

Note 3 to entry: Gemba visits help discover unknown requirements.

3.7
hoshin kanri
method for management and deployment of strategic organizational policy

Note 1 to entry: English translations include policy management, policy deployment, management by policy, and strategy deployment.

4 Basic concepts of QFD

4.1 Theory and principles of QFD

Quality function deployment is an approach for ensuring quality throughout but not necessarily at each stage of the product development process, starting with the initial product concept. In 1987, the co-founder of QFD, Yoji Akao, defined comprehensive QFD as converting the "consumers' demands into quality characteristics and developing a design quality for the finished product by systematically deploying the relationships between the demands and the characteristics, starting with the quality of each functional component and extending the deployment to the quality of each part and process. The overall quality of the product will be formed through this network of relationships."[10] Since that time, QFD users have extended QFD and its applicable methods and tools upstream in the product development process to initial project strategy and downstream to the commercialization and even retirement of the product from the market. The network of relationships becomes a framework for new product development. QFD can be applied to products, services, and processes (hereafter referred to as products).

As a quality method, the aim is to assure that decisions regarding product development have a defined and repeatable process, are based on factual information, have definable and measurable targets, involve all relevant business departments, and focus first and best efforts where they matter most to customers. QFD should begin upstream in the product development process in order to assure that decisions are made in this way, as downstream rework can be costly in terms of money and delays.

The principles of QFD are as follows:

a) prioritize information to focus;

b) understand how to cause good quality;

c) listen to the voice of the customer;

d) observe the customer's situation;

e) capture information from other sources;

f) improve internal communications through the transformation of information between perspectives.

4.2 QFD use of the word of function

In modern organizations, the "quality function" shall collaborate and coordinate with other functions (marketing, engineering, manufacturing, service support, information technology, and others involved in product development) in order to assure customer satisfaction with the resulting product. Thus, the quality function is deployed (hence, the term QFD) across critical business activities and ideally across the entire organization.

NOTE The term function is used in multiple ways in QFD. The following are some of the common uses.

In the term quality function deployment, function refers to the organizational units, in this case, the quality function that is often tasked with process control, improvement, inspection, and other related activities.

In the term function deployment, function refers to product function, defined in value engineering and function analysis as a verb (active) + noun (measurable) that describes what a product does but not how it does it regardless of the level or perspective.

4.3 Spirit of QFD

A commitment among all critical departments to work together for the benefit of the customer or stakeholder. A personal connection to the customer should be established.

As a central principle, customer needs or requirements shall be known or acquired and understood adequately by all relevant stakeholders. It shall be validated if product requirements meet the needs of the customer or stakeholder.

4.4 Display of information

Visual display of information improves communications. Due to the various organizational functions in the QFD team and the complexity of the information as it flows through the development and commercialization process, visual displays of the information are helpful. This is especially true in global organizations with many languages and cultures.

5 Integration of QFD and product development methods

5.1 QFD support for product development methods

Integration of QFD into new product development processes is both desirable and possible. Successful integration has been accomplished with other product development methods such as Stage-Gate™[1)] and product development support methods such as Design for Six Sigma, Design for Lean Sigma, and others. This may be done at an enterprise level, business group level, project level, or technology level. This integration should be guided by a QFD expert familiar with these methods.

NOTE 1 QFD is designed to link together the various phases of product development such as strategy, portfolio, marketing, competitiveness, systems, voice of customer, requirements analysis, concept development, optimization, change management, reliability, cost, safety, manufacturing, support, logistics, quality, and other product development phases. This linking assures that priorities at each phase are supported by downstream phases and decisions at each phase can be viewed for their impact on upstream phases. In this way, QFD improves both the product and the process by which it is created.

NOTE 2 QFD can integrate tools and methods from different new product development processes. Conversely, different new product development processes can utilize QFD tools and methods.

NOTE 3 The applicable tools lists are not exhaustive. They are meant to illustrate tools that have been effectively used in QFD. Other tools might also be useful according to the project.

5.2 Flow of product development with QFD

5.2.1 Organization of the QFD flow

The flow of QFD methods and tools may vary according to the organization and project requirements. Typically, they begin with broad concerns and through prioritization flow down to specifics. Figure 1 illustrates the organization of the clauses of this part of ISO 16355. Each box describes the general stage in product development such as project, customers, and so forth. Within each box are specific steps and their respective clause numbers such as "8.2.1 Identify customers" and so forth. Later in this part of ISO 16355, each clause will describe the step and suggest applicable methods and tools that can be used to accomplish the step. This helps align the voice of the business, voice of the customer, voice of the engineer, and voice of the process.

1) Stage-Gate™ 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.

5.2.2 Flow chart of product development with QFD

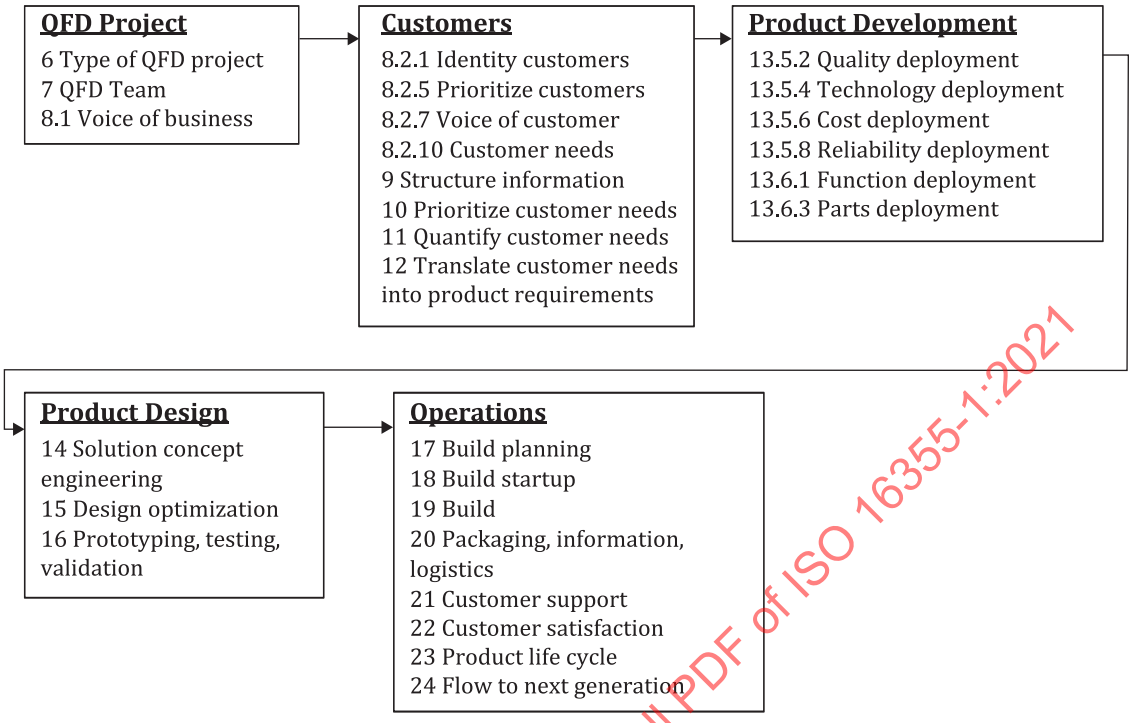

Figure 1 — Flow chart of product development with QFD

6 Types of QFD projects

6.1 General

QFD projects can encompass new developments, as well as generational improvements to existing products.

a) QFD can be applied to both existing and new markets, as well as to both existing and new technologies.

b) QFD projects can be driven by external sources such as market and customer demands, competitive threats or opportunities, technology change, regulatory changes, and other external factors, as well as internal sources such as cost reduction, manufacturing opportunities, new materials, knowledge management, and other internal factors.

c) QFD projects can focus on hardware, service, software, software as a service, process, systems, interface, or some combination. They can be either business-to-consumer (B2C) or business-to-business (B2B). Big, complex projects may benefit from increased customer involvement. Methods such as continuous QFD (see A.25) may be helpful.

d) QFD projects can be applied at any level: societal, environmental, end product, system, subsystem, component, production, material, process, service process, support, or supplier. Projects may progress upstream from micro detail to macro systems, downstream from macro to micro, or expand outward from a midstream level. QFD projects may have defined launches or may be continuous.

e) QFD may be employed at any management level from business operations to strategic business planning and control.

f) QFD projects may be used to document and preserve market and technical knowledge of the organization.

The QFD tools and the sequence in which they are used should be adapted to the type of project.

The QFD tools and sequence should be adapted to the management structure and culture and problems of each organization to improve participation, integration, and long-term utilization of the method. There is no “one way” to do QFD that fits all organizations.

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 A.22). In more recent years, organizational resource constraints have led to a quicker approach that addresses both complexity and speed (see A.23). It is consistent with quality methods in general and with customer-driven methods like QFD in particular that the methods and tools should 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.

NOTE QFD is not a method to design a product or process; it is an infrastructure to ensure the product or process satisfies customers.

6.2 Applicable methods and tools

a) Systems engineering

b) Stage-Gate™[2)]

c) Design for Six Sigma phase activities

d) Design for Lean

e) Cross-functional management swim-lane charts (see ISO/TR 16355-8:2017, Clause 20)

f) Knowledge management (see ISO 16355-5:2017, 9.3.7)

g) Continuous QFD (see A.25 and ISO 16355-2:2017, 9.2.5.15)

7 QFD team membership

7.1 QFD uses cross-functional 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.

7.2 Core team membership

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 information gaps from diminishing customer satisfaction.

7.3 Subject matter experts

Subject matter experts whose specialty is required to develop and review requirements may be invited as the project requirements flow down to different departments in the organization. Common experts include marketing (consumer insights, consumer experience, statisticians, conjoint analysis, survey design, and other marketing areas), engineering (electronics, components, value engineers, software,

2) Stage-Gate™ 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.

materials, packaging, and other engineering areas), manufacturing (stamping, forming, equipment, supply, industrial, and other manufacturing areas), quality (Six Sigma, statisticians, inspection, gage, design of experiments, supplier quality, and other areas activities), services (technical writers, technical support, phone centres, and other service areas), as well as other areas of expertise.

7.4 QFD team leadership

QFD team leaders or moderators should be trained in the QFD tools and methods in order to effectively lead the QFD project. Additional tools, as identified in the appendices, may be useful. Basic team facilitation and moderation skills are recommended. (See ISO 16355-5:2017, 7.4.)

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

8 QFD voices

8.1 Voice of business

8.1.1 Since QFD is applied to projects, these projects have many goals or objectives for the organization. Constraints may also exist. These goals may derive from development decisions and business strategy.

8.1.2 Business and project goals may include financial targets such as revenue, profit, and facility and resource optimization, marketing targets such as market opportunity, market share, market growth, and competitiveness, and others. (See ISO 16355-2:2017, 9.1.3.)

8.1.3 Constraints may include time/schedule, human resources and technical expertise, and cost/investment.

QFD is a quality method, so the goals and constraints should include a metric and measurement method, current performance level of the metric, desired performance level of the metric, timeframe in which to achieve the desired performance level of the metric, and who will judge if the desired performance level of the metric has been met within the timeframe.

8.1.4 Applicable methods and tools

a) Strategic planning methods

   1) Hoshin kanri (policy management) (see ISO 16355-2:2017, 9.1.2.2)

   2) Porter five force analysis (see ISO 16355-2:2017, 9.1.2.3)

   3) Kotler's market portfolio planning (see ISO 16355-2:2017, 9.1.2.4)

   4) Blue Ocean Strategy (see ISO 16355-2:2017, 9.1.2.5)

   5) New Lanchester strategy for sales and marketing (see ISO 16355-2:2017, 9.1.2.6)

b) Balanced scorecard (see ISO 16355-2:2017, 9.1.2.7.2)

c) Project prioritization and selection using the analytic hierarchy process (AHP) (see ISO 16355-2:2017, 9.1.2.8)

d) Project goals table (see A.2 and ISO 16355-2:2017, 9.1.3)

e) Project goals prioritization with AHP (see A.3 and ISO 16355-2:2017, 9.1.3.3)

f) Heterarchy diagram

8.1.5 Project scope

The project should also have a clearly defined scope in order to prevent scope drift and creep. (See ISO 16355-2:2017, 9.1.5.)

NOTE After market information is acquired, the scope can be adjusted to reflect new information regarding demand and competition.

8.1.6 Applicable methods and tools

a) Scope boundary analysis (see A.4 and ISO 16355-2:2017, 9.1.5.2)

b) Process beginning/end table (see A.5 and ISO 16355-2:2017, 9.1.5.3)

8.2 Voice of customer (VOC) or voice of stakeholder (VOS)

8.2.1 Definition of customer or stakeholder

A product provides benefit to one or more customers. There may also be a chain of involved customers or stakeholders including constituents (of a social service), end users and consumers, intermediate users such as dealers, installers, operators, maintenance, and other users and internal customers such as human resources, manufacturing, and other departments who reflect the underlying customer value network of delivery of the product to the user. The relationships among these various customers should be clarified. When many customers exist, they may be prioritized in order to focus resources first on high-priority customers. (See ISO 16355-2:2017, 9.2.1.)

8.2.2 Applicable methods and tools

a) Value chain mapping (see ISO 16355-2:2017, 9.2.1.2)

b) Analytic hierarchy process (AHP) (see A. 13 and ISO 16355-2:2017, 9.2.3)

c) User personae (see ISO 16355-2:2017, 9.2.1.3)

d) Stakeholder analysis (see ISO 16355-2:2017, 9.2.1.4)

8.2.3 Marketing perspective and engineering perspective

For product development, customers or stakeholders should be defined from both a marketing perspective (channel, region, size, and other related demographics) and an engineering perspective (who, what, when, where, why, and how the product will be or could be used). (See ISO 16355-2:2017, 9.2.2.)

NOTE Product use modes might be important in studies for parameter design for robust products and for reliability.

8.2.4 Applicable methods and tools

a) Customer value chain and network mapping (see ISO 16355-2:2017, 9.2.1.2)

b) Market segmentation

c) Customer segments table (see A.6 and ISO 16355-2:2017, 9.2.2.2)

d) User personae (see ISO 16355-2:2017, 9.2.1.3)

8.2.5 Prioritize customers or stakeholders

Customers or stakeholders should be prioritized and information acquisition should begin with high-priority customers whose satisfaction is most critical to achieving the business and project goals. (See ISO 16355-2:2017, 9.2.3.)

Customer identification and prioritization should be based on statistical information.

8.2.6 Applicable methods and tools

a) AHP (see A.13 and ISO 16355-2:2017, 9.2.3)

b) Project goals/customer segments matrix (see A.7 and ISO 16355-2:2017, Table 17)

c) Cluster analysis (see ISO 16355-3:2019, 9.4)

d) Factor analysis (see ISO 16355-3:2019, 9.6 and ISO/TR 16355-8:2017, 8.10)

e) Stakeholder analysis (see ISO 16355-2:2017, 9.2.1.4)

8.2.7 What is contained in the voice of customer (VOC) or voice of stakeholder (VOS)

VOC and VOS is raw, unprocessed information from the customer or stakeholder. It often includes complaints, needs, functional requirements, performance specifications and targets, solutions, components, materials, activities, information, and other customer or stakeholder statements. To be most useful, these may be sorted, analysed, structured, quantified, and prioritized by key customers.

8.2.8 Sources of VOC and VOS

VOC and VOS may be acquired through the applicable methods and tools. (See ISO 16355-2:2017, 9.2.5 and ISO 16355-4:2017, 9.1.2.)

Voice of customer or stakeholder may be obtained through non-quantitative and quantitative methods below. Surveys should be properly designed, tested, and evaluated.

8.2.9 Applicable methods and tools

a) Gemba visit checklist (see ISO 16355-2:2017, 9.2.5.2.2)

b) Customer process model (see A.8 and ISO 16355-2:2017, 9.2.5.2.3)

c) Gemba visit table (see A.9 and ISO 16355-2:2017, 9.2.5.2.4)

d) Customer support and help systems (see ISO 16355-2:2017, 9.2.5.4)

e) Focus groups (see ISO 16355-2:2017, 9.2.5.6)

f) Social media (see ISO 16355-2:2017, 9.2.5.7)

g) Questionnaires (see ISO 16355-2:2017, 9.2.5.8)

h) Interviews (see ISO 16355-2:2017, 9.2.5.9)

i) Customer satisfaction surveys (see ISO 16355-2:2017, 9.2.5.10)

j) Lead user analysis (see ISO 16355-2:2017, 9.2.5.11)

k) Warranty returns, complaints (see ISO 16355-2:2017, 9.2.5.12)

l) Conference papers, reports, and studies (see ISO 16355-2:2017, 9.2.5.17)

m) Sales call reports

n) Technical visits and maintenance records (see ISO 16355-2:2017, 9.2.5.13)

o) Continuous QFD (see A.25 and ISO 16355-2:2017, 9.2.5.15)

p) Design thinking (see ISO 16355-2:2017, 9.2.5.16)

q) Big data analytics

8.2.10 Translating VOC/VOS into customer needs

QFD project teams constrained by resources, budget, and time shall focus their efforts where they matter most to the customer. The customer, not the QFD team, should determine these priorities whenever possible. To get accurate priorities, VOC should be translated into an information set about which the customer has greater domain knowledge – customer needs.

Customer needs are defined in QFD as being benefits the customer receives when their problems are solved, their opportunities are enabled, or their image (self and to others) is enhanced, independent of the specific product or solution. The purpose is to derive true customer needs identifying and separating customer from possible 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. (See ISO 16355-4:2017, Clause 9.)

8.2.11 Applicable methods and tools

a) Cause-to-effect diagram (see ISO 16355-4:2017, 9.2.3)

b) Customer voice table (see A.10 and ISO 16355-4:2017, 9.2.4)

c) Focus groups (see ISO 16355-2:2017, 9.2.5.6)

d) Continuous QFD (see A.25 and ISO 16355-2:2017, 9.2.5.15)

9 Structuring information sets

9.1 General

To obtain accurate, unbiased, and unambiguous prioritization and quantification and to reduce the effort of both customers and team members to obtain, these information should be organized into a logical structure. Structuring should be done by members of the group that “own” the information set and have greater domain knowledge.

Customer needs should be structured by the customer.

Information set structuring should assure that information groups are mutually exclusive and collectively exhaustive (MECE) to ensure no overlapping or missing elements. Overlapping or missing elements can reduce the accuracy of later analyses such as prioritization. (See ISO 16355-4:2017, Clause 10.)

9.2 Applicable tools and methods

a) Affinity diagram (see A.11 and ISO 16355-4:2017, 10.2)

b) Hierarchy diagram (see A.12 and ISO 16355-4:2017, Clause 10.3)

c) Networks

d) Heterarchy diagram (network of elements sharing common elements in which each element shares the same horizontal position of power and authority)

e) Mind maps

f) Key needs analysis

10 Prioritization

10.1 General

In order to focus where maximum benefit to customers or stakeholders is provided with minimal effort by the QFD team, prioritization of the information set should not be neglected.

Prioritization should be done by the group that "owns" the information.

Customer needs should be prioritized by the customer.

Priorities should be as accurate, unbiased, and unambiguous as possible as they may serve later QFD activities related to cost and resource allocation. Thus, the mathematical limitations of different numerical scales should not be ignored.

Ordinal ranking and rating scale numbers do not support +, –, ×, or / mathematical functions. Ratio scale numbers (also referred to as absolute relative scale with meaningful ratios) should be used if these mathematical functions are to be used later. (See ISO 16355-4:2017, Clause 11.)

10.2 Applicable tools and methods

a) Analytic hierarchy process (AHP) (A.13 and ISO 16355-4:2017, 11.2)

b) Analytic network process (ANP) (see ISO 16355-3:2019, 9.1)

c) Fuzzy AHP

d) Fuzzy ANP

e) Continuous QFD (A.25 and ISO 16355-2:2017, 9.2.5.15)

11 Quantification

11.1 General

Quantification of customer needs may include customer current and hoped-for satisfaction levels, customer scoring of the magnitude of current product and benchmarking competitive alternatives, and other factors that reflect customer value. Quantification of customer needs may also include minimum acceptance levels (below which there is no real benefit) and maximum thresholds (beyond which there is no additional benefit). Quantifications may be used as adjustments to recalculate customer needs priorities to reflect market opportunities and competitive threats.

Quantification values should not neglect the limitations of different numerical scales. Ratio scale numbers (also referred to as absolute relative scale with meaningful ratios) should be used if the mathematical functions of +, –, ×, and / are to be used in the adjustment recalculations.

11.2 Applicable tools and methods

a) Focus groups (see ISO 16355-2:2017, 9.2.5.6)

b) Interviews (see ISO 16355-2:2017, 9.2.5.9)

c) Porter five force analysis (see ISO 16355-2:2017, 9.1.2.3)

d) New Lanchester strategy for sales and marketing (see ISO 16355-2:2017, 9.1.2.6)

e) Quality planning table (see A.14 and see ISO 16355-4:2017, 12.2)

f) New Kano model (see ISO 16355-5:2017, 10.3.4.4)

12 Translation of one information set into another

12.1 General

QFD flows information sets through the various development and commercialization functions of the organization. These flows are called deployments and often require the language of one information set to be transformed into another information set or a single information set broken down into more details. This translation can be visually displayed to check for completeness and accuracy and can be mathematically quantified for complex information sets. (See ISO 16355-5:2017, Clause 9.)

12.2 Applicable tools and methods

a) Maximum value table for critical needs (see A.15 and ISO 16355-5:2017, 9.2)

b) House of Quality and other L-matrices for comprehensive studies (see A.16 and ISO 16355-5:2017, 9.3)

c) Other tools in the new management and planning tool set (see A.21 and ISO 16355-2:2017, 8.2)

13 Transfer of prioritization and quantification from one information set into another

13.1 Transfer of prioritization

Prioritizations and quantifications of one information set may be transferred into prioritizations and quantifications of another information set. In a QFD L-matrix, prioritization is done with weights to show the strength of relationship or contribution of the columns of the matrix to the rows of the matrix. In the House of Quality matrix, weights quantify the relationship or contribution between customer needs and functional requirements. Setting targets for the functional requirements can be improved by examining their weighted contribution to customer needs. (See ISO 16355-5:2017, 10.2.)

QFD can use many types of matrices for transferring priorities and quantifications. The House of Quality is one instance of an L-matrix. It is so named because the original Japanese labels had the word “quality” in both axes (demanded quality in the rows and quality characteristics in the columns). Other matrices include information related to functions, parts, technologies, failure modes, cost, and other dimensions of the design and development process. It is recommended to refer to matrices by the information in the “rows/columns” matrix. Thus, in this format, the House of Quality can be referred to as the customer needs/functional requirements matrix. In addition to the L-matrix, QFD can use T-matrices, Y-matrices, C-matrices, and others.

NOTE There are different approaches to quantifying weighted contributions or relationships. An approach that is appropriate for the analysis can be used.

a) Classical QFD matrices using three levels of relationships described as weak (W), moderate (M), strong (S) and assigned values of 1, 2, 4 or 1, 3, 5 or 1, 3, 9, respectively.

   NOTE Strengths of this approach: familiarity, 1, 3, 9 addresses problem of transferred priorities being too close in value. Weaknesses of this approach: with only three levels, QFD teams might struggle to agree on the appropriate level, these are ordinal scales without fixed intervals so that resulting QFD math functions have results that tell order but not relative importance.

b) Modern QFD matrices use five or nine levels of relationships described as weak (W), moderate (M), strong (S), very strong (V), or extremely strong (X), as well as intervals such as weak-to-moderate

(W-M), and so forth. Assigned values can be adapted using the analytic hierarchy process but the following are commonly used:

1) Five levels: W (0,069), M (0,135), S (0,267), V (0,518), X (1,00);

2) Nine levels: W (0,059), W-M (0,079), M (0,112), M-S (0,162), S (0,237), S-V (0,344), V (0,498), V-X (0,712), X (1,000).

NOTE Strengths of this approach: When the level of relationship requires a judgment, human short-term memory capacity is best when there are 7 ± 2 (5 or 9) levels. This allows first a judgment of high, medium, low, and then within each category, another high, medium, low. This creates nine levels ranging from high-high to low-low, giving QFD teams more relationship levels to select from, and thus improving agreement. These ordinal judgments are transformed into absolute scale values with fixed intervals using the AHP principle eigenvector so that resulting QFD math functions tell both order and relative importance. Weaknesses of this approach: unfamiliar but has short learning curve, commercial QFD software might not support assigning ratio scale values so QFD team may need to build own spreadsheet. (See ISO 16355-5:2017, 10.2.1.)

c) Nonlinear relationships may be used in cases where other scales are justified.

Display of relationships or contribution may include icons representing the various levels. Icons should visually increase according to the strength of relationship or contribution they reflect, from weak to extremely strong.

Classical QFD icons for 3 levels:

Weak △ Moderate ○ Strong ◎

Modern QFD icons for 5 or 9 levels:

W ○ W-M ◔ M ◔ M-S ◑ S ◑ S-V ◑ V ◕ V-X ◕ X ●

Setting targets for the functional requirements can be improved by examining their weighted contribution to customer needs.

d) Unweighted matrices may also be used to manage knowledge and interactions of processes, materials, facilities, or tasks.

13.2 Applicable tools and methods

a) Maximum value table (see A.15 and ISO 16355-5:2017, 9.2)

b) Customer needs/functional requirements (House of Quality), L- and other matrices (see A.16 and ISO 16355-5:2017, 9.3)

c) Analytic hierarchy process (AHP) (see A.13 and ISO 16355-4:2017, 11.2)

13.3 Transfer of quantification

Other quantifications can be transferred from the input information to the output information based on priorities, number and strength of relationships, and technical challenge, technical advantage, New Kano Model categories.

The input targets may be translated into output targets. In some matrices, the relationship between the x and y can be determined through testing or given in scientific knowledge. (See ISO 16355-5:2017, 10.3.)

13.4 Applicable tools and methods

a) Quality planning table (see A.14 and ISO 16355-4:2017, 12.2)

b) Design planning table (see A.17 and ISO 16355-5:2017, 10.3.4.1)

13.5 Transferring deployment sets by dimensions

13.5.1 General

Transfers of prioritization and quantification can be done in deployment sets organized into both dimensions (displayed vertically in A.22) and levels (displayed horizontally). The layout of the deployment will depend on the overall development process. (See ISO 16355-5:2017, 10.4.)

13.5.2 Quality deployment

Quality deployment focuses on functional requirements and performance and their targets at the product level, system level, subsystem level, component level, and process level. Deployments for service and software products may be different. For example, iterative/incremental processes like software development with scrum or other agile processes, the deployment layout may reflect an explicit iterative/incremental structure. (See ISO 16355-5:2017, 10.4.2.)

13.5.3 Applicable tools and methods

a) Deployment flow diagram (see A.15)

b) Affinity diagram (see A.11 and ISO 16355-4:2017, 10.2)

c) Hierarchy diagram (see A.12 and ISO 16355-4:2017, Clause 10.3)

d) Effect-to-cause diagram (see ISO 16355-5:2017, 9.2.2)

e) Customer needs to functional requirements extraction (see ISO 16355-5:2017, 9.3.6.2.2)

NOTE 1 4.1 mentions the historical term quality characteristics. The more general term functional requirements is used to address non-manufacturing uses of QFD such as service, software, and business processes.

NOTE 2 Some House of Quality software programs allow for directional indicators for functional requirements. This can be misleading since most functional requirements will change direction depending on the customer need it relates to.

EXAMPLE For the functional requirement of “size” for an umbrella, bigger is better for the customer need “I stay dry in the rain.” However, smaller is better for the customer need “I can carry easily.”

f) House of Quality and other L-matrices (see A.16 and ISO 16355-5:2017, 9.3.6.2.3)

The functional requirements correlation matrix or roof of the House of Quality is enabling technology dependent. That is, the positive and negative correlations will change depending on the technology employed. It is recommended that this be used in technology deployment for each specific technology, rather than in quality deployment where the functional requirements are still technology agnostic.

NOTE Monte Carlo simulations have been run to improve House of Quality.

g) Parameter design for robust products (see ISO/TS 16355-6:2019)

h) Analytic hierarchy process (see A.13 and ISO 16355-4:2017, 11.2)

i) Kansei engineering for emotional quality (see A.19 and ISO/TR 16355-8:2017, 8.1)

j) Knowledge management (see ISO 16355-5:2017, 9.3.7)

13.5.4 Technology deployment

Technology deployment focuses on discovery and quality assurance of new technologies at the product level, system level, subsystem level, component level, and equipment/process level. This may include invention, patents and intellectual property search, registrations, licensing, and other forms of

acquiring technology. Deployments for service and software may be different. (See ISO 16355-5:2017, 10.4.3.)

Insufficient technologies to fulfil customer needs may be referred to research and development departments to begin development of future technologies.

13.5.5 Applicable tools and methods

a) Functional requirements correlation matrix, often called the "roof" of the House of Quality

   The functional requirements correlation matrix, or roof, is enabling technology dependent. That is, the positive and negative correlations will change depending on the technology employed. It is recommended that this be used in technology deployment rather than in quality deployment, where the functional requirements are still technology agnostic. (See ISO 16355-5:2017, 10.4.3.4.1.1.)

b) Theory of inventive problem solving (TRIZ) (see ISO 16355-5:2017, 10.4.3.4)

c) deBono's lateral thinking

d) Reverse QFD (see A.20 and ISO 16355-5:2017, 10.4.3.5.1.2)

e) Reviewed dendrogram (see ISO 16355-5:2017, 10.4.3.8.2)

f) Super Pugh concept selection with AHP (see A.18 and ISO 16355-5:2017, 10.4.3.7.2)

g) Conjoint analysis (see ISO 16355-3:2019, 9.3)

h) New Kano model (see ISO 16355-5:2017, 10.3.4.4)

i) Failure mode and effects analysis (FMEA) at the system, subsystem, module, component, process levels (see ISO 16355-5:2017, 10.4.5.8 and ISO/TR 16355-8:2017, 9.8 and 13.4)

13.5.6 Cost deployment

Cost deployment focuses on target costing and other finite constraints such as schedule, resource, and weight at the product, system, subsystem, module, component, and process levels. Deployments for service and software may be different. (See ISO 16355-5:2017, 10.4.4.)

13.5.7 Applicable tools and methods

a) Value analysis (see ISO/TR 16355-8:2017, 9.4.3)

b) Value engineering (see ISO/TR 16355-8:2017, 9.4.4)

c) Fast diagrams

d) Parametric cost estimation (see ISO 16355-5:2017, 10.4.4.6)

e) L-matrices with proportional distribution (see ISO 16355-5:2017, 10.2.4.4)

f) Conjoint analysis (see ISO 16355-3:2019, 9.3)

13.5.8 Reliability deployment

Reliability deployment focuses on product life and failure modes at the product, system, subsystem, module, component, and process levels. Deployments for service and software may be different. (See ISO 16355-5:2017, 10.4.5.)

13.5.9 Applicable tools and methods

a) Fault tree analysis (see ISO 16355-5:2017, 10.4.5.4)

b) Failure mode and effects analysis (FMEA) (see ISO 16355-5:2017, 10.4.5.8)

c) Failure mode, effects and criticality analysis (FMECA) (see ISO 16355-5:2017, 10.4.5.8.4)

d) Failure mode effects and diagnostic analysis (FMEDA) (see ISO 16355-5:2017, 10.4.5.8.4)

e) Anticipatory failure determination (see ISO 16355-5:2017, 10.4.5.8.3)

f) Lifetime estimation

g) V-model of systems engineering

h) Functional requirements correlation matrix, often called the "roof" of the House of Quality

i) Process decision program chart (PDPC) (see ISO 16355-5:2017, 10.4.5.8.4)

13.5.10 Safety deployment

Safety deployment focuses on user safety, production safety, materials safety, toxicology, hygiene and sanitation, environmental safety and sustainability.

13.5.11 Security deployment (see ISO 16355-7)

13.5.11.1 Organizational information

Security deployment of organizational information includes protection of intellectual property, trade secrets, classified information, communications, and other unauthorized uses.

13.5.11.2 Personal information

Security deployment of personal information includes protection of identity, financial information, health records, and related information, communications, and other unauthorized uses.

13.5.11.3 Systems

Security deployment of systems includes unauthorized use or access of a system, including but not limited to, computer operating systems, device operating systems such as industrial equipment, medical devices, automobiles, and others.

13.5.12 Lifestyle and emotional quality deployment

Lifestyle and emotional quality deployment, which focus on non-functional requirements such as aesthetics, attraction. (See ISO/TR 16355-8:2017, Clause 8.)

13.5.13 Applicable tools and methods

a) Ergonomics and human factors

b) Kansei engineering (see ISO/TR 16355-8:2017, Clause 8.1)

13.6 Transferring deployment sets by levels

13.6.1 Function deployment

Function deployment examines the relationships between function and quality, technology, cost, and reliability. Function deployment may also be used to examine modularity of systems and subsystems.

13.6.2 Applicable tools and methods

a) Function analysis (see ISO 16355-5:2017, 10.5.2)

b) Function tree (see ISO 16355-5:2017, 10.4.2.3.3)

c) L-matrices (see ISO 16355-5:2017, 9.3)

d) Kansei engineering (attractive function) (see ISO/TR 16355-8:2017, Clause 8.1)

e) Human factors analysis

f) Usability studies

13.6.3 Parts deployment

Parts deployment examines the relationships between component parts and quality, technology, cost, and reliability. Deployments for service and software may be different. It may also refer to components. (See ISO/TR 16355-8:2017, Clause 9.)

13.6.4 Applicable tools and methods

a) Bill of materials (see ISO/TR 16355-8:2017, 9.4.2)

b) L-matrices (see ISO/TR 16355-8:2017, 9.3)

13.6.5 Manufacturing and process deployments

Manufacturing and process deployments examine the relationships between manufacturing, production, or other build/implementation methods and equipment and quality, technology, cost, and reliability. It may support agile, lean, and world class manufacturing activities. Deployments for service and software may be different. (See ISO/TR 16355-8:2017, Clause 10.)

13.6.6 Applicable tools and methods

a) Design for X (DfX) studies (manufacturability, assembly, disassembly, safety, serviceability, recyclability, and other product development dimensions)

b) Advanced product quality planning (APQP)

c) Make–or-buy analysis (see ISO/TR 16355-8:2017, 12.4)

d) Design for lean

e) Lean manufacturing

f) Theory of constraints

g) Flexible manufacturing

h) Specific Design for Six Sigma elements

i) Six Sigma

j) World class manufacturing

13.6.7 Project work or task management

Project work or task management concerns related to managing resources, skills, tools and testing, cost, milestone and prototypes schedules, risks, changes to scope and schedule, and other areas of project management.

14 Solution concept engineering

14.1 General

Based upon the priority and design target levels, both existing solutions and new technology concepts may be explored. Helpful activities include innovation, invention, product generation strategic portfolio analysis, concept hybridization, concept selection, feasibility studies, resource planning (project management), intellectual property (patent screen and patent of inventions), technology risk, robust design, design optimization and parameter design.

14.2 Applicable tools and methods

a) TRIZ (see ISO 16355-5:2017, 10.4.3.4)

b) deBono's lateral thinking

c) Reviewed dendrogram (see ISO 16355-5:2017, 10.4.3.8.2)

d) Super Pugh concept selection with AHP (see A.18 and ISO 16355-5:2017, 10.4.3.7.2.5)

e) Evolutionary 7 (e-7) QFD tools

15 Design optimization

15.1 Parameter design for robustness

Parameter design can be applied in product design stage to identify optimum nominal value of design parameter based on assessment of robustness of its function. When products are robust, those products cause minimal environmental and socio-economic losses (including loss to the manufacturer and users) due to poor quality caused by functional variability throughout its usable lifetime from shipping to final disposal. (See ISO/TS 16355-6:2019; ISO/TR 16355-8:2017, 12.3; and ISO 16336:2014.)

15.2 Tolerance design

Part tolerance design may be important to quality and cost in the manufacturing process of complex products. It may address issues related to equipment and tooling deterioration and manufacturing conditions. It may also be useful to supplier quality assurance. (See ISO/TS 16355-6:2019 and ISO 16337:2021.)

15.3 Applicable tools and methods

a) Design of experiments (see ISO/TS 16355-6:2019; ISO/TR 16355-8:2017, 12.3; and ISO 16336:2014)

b) Taguchi's signal-to-noise ratio may be used as a measure of robustness and the procedures of parameter design to design robust products utilizing this measure (see ISO 16336)

c) Multiple response surface optimization

d) Sensitivity analysis

e) Monte Carlo and other simulation methods

f) Evolutionary 7 (e-7) QFD tools

16 Prototyping, testing, and validation

16.1 General

High-priority characteristics, parameters, functions, and other design and development dimensions should be tested for customer acceptance, human factors/usability, efficacy, regulatory compliance, manufacturability, reliability, safety, and other factors. Deployments for service and software may be different.

16.2 Applicable tools and methods

a) Test deployment (see ISO/TR 16355-8:2017, 11.2)

b) Focus groups (see ISO/TR 16355-8:2017, 11.3.2)

c) Statistical methods such as factor analysis, conjoint analysis (see ISO/TR 16355-8:2017, 11.3.4)

d) New Kano model (see ISO 16355-5:2017, 10.3.4.4.2 and ISO/TR 16355-8:2017, 11.3.3)

e) Risk analysis

f) Usability studies

g) Design review (see ISO/TR 16355-8:2017, 11.4)

h) Component FMEA (see ISO/TR 16355-8:2017, 9.8)

17 Build planning

17.1 General

Build planning (manufacturing and pre-production planning, quality planning, pre-launch control plan, service planning, software architecture, and other planning activities) should be linked to the design plan (procurement, supply chain management, process flow charts, process validation, material handling and storage, equipment and tooling, floor plan layout).

Equipment and facilities needed to build systems, subsystems, and components should be investigated for critical performance, functionality, quality capabilities that meet or exceed their specifications, process parameter optimization, process capability studies.

Make or buy decisions, as well as supplier qualification, production part approval plan (PPAP), and supplier quality assurance may be done. Periodic critical component supplier assessment visits may also be done. Deployment for service and software may be different.

17.2 Applicable tools and methods

a) Design of experiments (see ISO/TS 16355-6:2019; ISO/TR 16355-8:2017, 12.3; and ISO 16336:2014)

b) Tolerance design (see ISO 16337:2021)

c) Supplier and vendor selection using AHP

d) Supply chain management

e) Task deployment table (see ISO/TR 16355-8:2017, 12.5)

f) Parameter optimization (see ISO/TS 16355-6:2019; ISO/TR 16355-8:2017, 12.3; and ISO 16336:2014)

g) Internal and supplier process capability studies

h) Production part approval plan (PPAP)

i) Process FMEA (see ISO/TR 16355-8:2017, 13.4)

j) Design for Lean

k) Specific Design for Six Sigma elements

l) Design for X (DfX) studies, for manufacturability, assembly

18 Build start-up

18.1 General

Build start-up (manufacturing, production, training, process planning, quality inspection, and other activities) should be linked to the manufacturing plan.

18.2 Applicable tools and methods

a) Value stream mapping for lean processes

b) Production control plans

c) Control standards

d) Inspection standards

e) Quality control process charts (see ISO/TR 16355-8:2017, 13.5.1)

f) Risk assessment

19 Build

19.1 General

Quality checks during full production launch, service start-up, software detailed design, and other activities may be made.

19.2 Applicable tools and methods

a) Process improvement

b) 5S (from Japanese words for workplace improvements meaning sort, straighten, shine, standardize, and sustain)

c) Poka-yoke (mistake proofing)

d) Statistical process control

e) Kaizen

f) Design for Six Sigma phase activities, elements and tools

g) Six Sigma method to design, measure, analyse, improve, and control (DMAIC) and quality improvement teams linked to design and build plans

h) 7 or 8 discipline charts (7-D, 8-D)

20 Packaging design, logistics, channel management, consumer information, and operating instructions

20.1 General

Packaging engineers may be involved at the design phase to better protect customer safety for food, pharmaceutical, medical, and similar products from damage, loss of sterility, insect and debris infiltration, and other damages. Similarly, packaging engineers should be involved at the design phase to better protect product integrity from damage and loss of usability during shipping and handling. Packaging engineers should be involved with marketing and sales to assure attractiveness, legibility of legal and marketing language, retail-applied labelling, and shelf/point-of-purchase plan-o-gramming. Similar considerations should be made to product usage, warnings and cautions, installation and operating instructions, and other information. (See ISO/TR 16355-8:2017, Clause 15.)

20.2 Applicable tools and methods

a) Ergonomics and human factors

20.3 Logistics

Planners should be involved with packaging to better protect product during shipping, storage, and handling, particularly for effects of temperature, humidity, expiry dates, and other relevant factors. Other considerations may be packaging size to optimize transportation concerns for weight, dimensions, material handling.

20.4 Marketing claims

Validation of marketing claims against requirements of regulatory agencies. (See ISO/TR 16355-8:2017, 15.4.)

21 Customer support

21.1 General

Customer support (technical, sales, and other field activities) and service (including parts, service training, and other support activities) may be made. 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, and bronze) should be created in line with customer expectations and needs. (See ISO/TR 16355-8:2017, Clause 16.)

21.2 Applicable tools and methods

a) Ergonomics and human factors

b) Technical visits and maintenance records

22 Customer satisfaction

22.1 General

Customer feedback related to new features, new complaints or concerns, competitive offerings, and other market information should be surveyed and fed back to improvement teams, as well as fed forward to next generation design. (See ISO/TR 16355-8:2017, Clause 17.)

22.2 Applicable tools and methods

a) Customer satisfaction surveys

   Sampling surveys should be done to periodically test market for shifts in customer priorities, competitive alternatives, and responses to promotions.

23 Product end-of-life disposal, recycle, reuse, and other sustainability concerns

23.1 General

Products may need to be disposed of in ways that comply with local regulations, as well as consumer and public sentiment. This may include design-for-reuse, design-for-recycling. Concerns for safety, environmental impact, long-term effects, and other considerations should be studies, especially in terms of new parts, materials, and processes. (See ISO/TR 16355-8:2017, Clause 18.)

23.2 Applicable tools and methods

a) Design of experiments

b) Taguchi methods

24 Flow to next generation development

24.1 General

Customer satisfaction surveys confirm that product met design and marketing intent. Changes in market priorities, new technologies, new market opportunities (industry, geography, segments) should be explored for next generation. This may include QFD models for customer-driven, technology-driven, cost-driven, manufacturing-driven, regulatory-driven, and other drivers. It may include hardware, software, service, interface, or any combination thereof. (See ISO/TR 16355-8:2017, Clause 19.)

24.2 Applicable tools and methods

a) Cross-functional management swim-lane charts (see ISO/TR 16355-8:2017, Clause 20)

b) Customer satisfaction surveys (see ISO/TR 16355-8:2017, 17.1)

Annex A
(informative)

Examples of applicable methods and tools

NOTE 1 Details of how these methods and tools are integrated and applied within QFD are explained in the cited books and papers. The examples below are from QFD application case study papers presented at conferences and in journals to illustrate how the methods and tools can be used in QFD.

NOTE 2 QFD can integrate with methods and tools from many product development methods. The methods and tools in this Annex and in the Bibliography are not an exhaustive list. Some references are instructional and some show how they integrate with other methods and tools in QFD.

A.1 QFD Tools Matrix

This table indicates which methods and tools have been used in QFD applications and research. Related books and documents with detailed explanations are cited in the Bibliography at the end. This table can be used to look up methods and tools which are arranged in alphabetical order in the rows to see if there is a relationship (as indicated by O) with the QFD steps and section numbers in this document. The table can also be used to look up each QFD step and clause number and determine which methods and tools can help in that activity.

Table A.1 — QFD Tools Matrix

	QFD Process Steps																						
	QFD project			Customers						Product development							Product design			Operations				
QFD and related tools and Methods (see bibliography for references)	6 Type of QFD project	7 QFD team	8.1 Voice of business	8.2.1 Identify customers	8.2.5 Prioritize customers	8.2.7 Voice of customer	8.2.10 Customer needs	10 Prioritize customer needs	11 Quantify customer needs	13.5.2 Quality deployment	13.5.4 Technology deployment	13.5.6 Cost deployment	13.5.8 Reliability deployment	13.6.1 Function deployment	13.6.3 Parts deployment	13.6.5 Manufacturing deployment	14 Solution concept engineering	15 Design optimization	16 Prototyping testing, validation	17 Build planning	20 Packaging, information, logistics	21 Customer support	22 Customer satisfaction	23 Product life cycle
5S (Reference[96])																				0	0			
7- and 8-D charts (Reference[30])																				0				
7 management and planning tools (A.21) (References,[89],[92] and[15])										0			0	0	0									
7 product planning tools (Reference[43])																								
Advanced product quality planning (APQP) (Reference[13])																0								
Affinity diagram (A.11) (References[89] and[92])							0			0														
Analytic hierarchy process (AHP) (A.13) (References,[108],[110],[111] and[47])			0	0	0			0		0										0				
Analytic network process (ANP) (References[109] and[65])								0																
Anticipatory failure determination (References[63] and[64])													0											
Balanced scorecard (Reference[55])			0																					
Bill of materials (Reference[103])															0									
Blitz QFD® (A.23) (References[131] and[84])				0		0	0	0		0	0	0	0	0	0	0			0	0	0	0		

[a] Stage-Gate™ 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.

Table A.1 *(continued)*

	QFD Process Steps																						
	QFD project			**Customers**						**Product development**							**Product design**			**Operations**				
QFD and related tools and Methods (see bibliography for references)	6 Type of QFD project	7 QFD team	8.1 Voice of business	8.2.1 Identity customers	8.2.5 Prioritize customers	8.2.7 Voice of customer	8.2.10 Customer needs	10 Prioritize customer needs	11 Quantify customer needs	13.5.2 Quality deployment	13.5.4 Technology deployment	13.5.6 Cost deployment	13.5.8 Reliability deployment	13.6.1 Function deployment	13.6.3 Parts deployment	13.6.5 Manufacturing deployment	14 Solution concept engineering	15 Design optimization	16 Prototyping testing, validation	17 Build planning	20 Packaging, information, logistics	21 Customer support	22 Customer satisfaction	23 Product life cycle
Blue Ocean Strategy (Reference[68])			0	0																			
Cause-and-effect diagram (References[90] and[78])					0					0													
Cluster analysis (Reference[45])					0		0																
Component (part) FMEA (References[10] and[119])																			0				
Conjoint analysis (References[42] and[94])											0	0							0				
Continuous QFD (A.25) (References[50] and[49])	0			0		0	0	0															
Control standards (References[10] and[99])																				0		0	
Cross-functional management Swim-lane charts (Reference[90])	0	0																					0
Customer process model (A.8) (References[17] and[39])						0																0	
Customer satisfaction surveys (Reference[61])						0																0	0	0
Customer segments table (A.6) (Reference[39])					0				0														
Customer support and help systems (Reference[85])						0	0		0													0	
Customer voice table (A.10) (Reference[46])							0		0														
De Bono's lateral thinking (Reference[26])											0						0						

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Table A.1 *(continued)*

QFD and related tools and Methods (see bibliography for references)	QFD Process Steps																						
	QFD project			Customers						Product development							Product design			Operations				
	6 Type of QFD project	7 QFD team	8.1 Voice of business	8.2.1 Identify customers	8.2.5 Prioritize customers	8.2.7 Voice of customer	8.2.10 Customer needs	10 Prioritize customer needs	11 Quantify customer needs	13.5.2 Quality deployment	13.5.4 Technology deployment	13.5.6 Cost deployment	13.5.8 Reliability deployment	13.6.1 Function deployment	13.6.3 Parts deployment	13.6.5 Manufacturing deployment	14 Solution concept engineering	15 Design optimization	16 Prototyping testing, validation	17 Build planning	20 Packaging, information, logistics	21 Customer support	22 Customer satisfaction	23 Product life cycle
Deployment flow diagram (A.22, A.23, A.24) (References,[10],[51],[131] and[84])										0	0													
Design FMEA and analogous versions for safety, security (References,[10],[90] and[119])											0		0				0							
Design for lean (Reference[84])	0	0														0	0			0				
Design for Six Sigma (References[54],[24],[133],[121])	0	0														0	0	0	0	0				
Design planning table (A.17) (Reference[59])										0								0	0	0				
Design for X (DfX) studies (Reference[71])																0				0				
Design of experiments (References[97] and[101])																		0		0				0
Design review (Reference[10])																			0					
Design thinking (Reference[112])				0		0	0																	
Evolutionary 7 (e-7) QFD tools (Reference[91])																	0	0						
Ergonomics and human factors (Reference[67])				0		0	0							0							0	0		
Factor analysis (Reference[45])					0														0					
Failure mode and effects analysis (FMEA) (References[10] and[119])											0		0						0					

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Table A.1 *(continued)*

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	QFD project			**Customers**						**Product development**							**Product design**			**Operations**				
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Failure mode effects and diagnostic analysis (FMEDA) (Reference[19])													0		0	0			0				
Failure mode, effects and criticality analysis (FMECA) (Reference[114])													0						0				
FAST diagrams (Reference[115])												0											
Fault tree analysis (Reference[10])													0					0	0				
Flexible manufacturing (Reference[129])																0				0			
Focus groups (Reference[31])						0	0		0										0				
Function analysis (References,[10],[115] and[116])														0									
Function tree (Reference[78])														0									
Functional requirements correlation matrix, "roof" of the House of Quality (Reference[22])													0				0	0					
Fuzzy AHP (Reference[73])								0															
Fuzzy ANP (Reference[60])								0															
Gemba visit checklist (Reference[87])				0		0																	
Gemba visit table (A.9) (Reference[53])						0																	
Heterarchy diagram (Reference[35])			0				0																

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Hierarchy diagram (A.12) (References [83], [92] and[89])							0			0														
Hoshin kanri (policy management) (References,[11],[62] and[125])	0	0	0																					
House of Quality and other L-matrices (A.16) (References,[69],[10],[78],[92],[83] and[89])										0	0	0	0	0	0									
Inspection standards (Reference[10])																				0				
Interviews (References[95] and[104])						0	0		0															
Kaizen (Reference[57])																				0				
(New) Kano model (References[62] and[105])				0					0		0								0					0
Kansei engineering for emotional quality (A.19) (References[40] and[124])						0	0			0				0										
Key needs analysis (Reference[46])							0																	
Knowledge management (Reference[12])										0														
Kotler's market portfolio planning (Reference[72])			0																					
Lead user analysis (Reference[118])						0																		
Lean manufacturing (Reference[25])																0								

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Lifetime estimation (Reference[74])													0											0
L-matrices (References[89] and[92])												0		0	0									
Make/buy analysis (Reference[33])												0				0								
Market segmentation (References,[72],[123] and[105])				0	0	0	0	0	0															0
Maximum value table for critical needs (A.15) (References,[131],[46] and[39])										0														
Mind maps (Reference[77])							0																	
Monte Carlo simulations (Reference[66])										0								0						
Multiple response surface optimization (Reference[88])																		0						
Networks (Reference[65])							0																	
New Lanchester strategy for sales and marketing (References[128] and[113])			0						0															
Parameter design for robust products (Reference[21] and[58])										0														
Parameter optimization (Reference[21] and[58])																		0		0				
Parametric cost estimation (Reference[27])												0												
Poka-yoke (Reference[117])																				0				
Porter five force analysis (Reference[48])			0						0															

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Process Beginning/ End table (A.5) (Reference[20])		0	0																					
Process capability studies for internal and suppliers (Reference[28])																				0				
Process decision program chart (PDPC) (References[89] and[92])													0											
Process FMEA (References[10] and[119])													0			0			0	0				
Process improvement (References,[130],[37] and[56])																				0				
Production control plans (References[10] and[37])																				0				
Production part approval plan (PPAP) (Reference[14])																				0				
Project goals table (A.2) (Reference[59])			0																					
Project goals/customer segments matrix (A.7) (Reference[104])				0	0			0																
(Super) Pugh concept selection with AHP (A.18) (References,[100],[134] and[69])											0						0							
Quality control process charts (References[10] and[90])									0											0				
Quality planning table (A.14) (References[10] and[59])									0															
Questionnaires (References[43] and[85])				0	0	0	0	0	0														0	

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Reliability deployment (References[69] and[10])													0											0
Reverse QFD (A.20) (References,[52],[61] and[86])											0											0		
Risk analysis (References[32] and[63])			0	0	0				0										0					
Risk assessment (Reference[24])			0	0	0				0											0				
Sales call reports (References[76] and[90])						0																0	0	
Scope boundary analysis (A.4) (Reference[120])			0			0																		
Sensitivity analysis (Reference[24])									0									0						
Six Sigma and DMAIC (References[16] and[104])																0				0				
Social media (Reference[85])				0		0																		
Stage-Gate™a) (References[82] and[23])	0	0																						
Stakeholder analysis (References[98] and[120])				0	0																			
Statistical process control (References[9] and[126])										0	0				0	0				0				
Supply chain management (Reference[41])																	0	0	0	0	0			0
Systems engineering (References[79] and[38])	0																							
Taguchi methods (References[97] and[101])																		0		0				0

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Task deployment table (References[75] and[80])																				0				
Technical visits and maintenance Records (References[44] and[34])						0																	0	
Test deployment (References[32] and [127])																			0					
Theory of constraints (References[132] and[102])																0								
Tolerance design (Reference[16])													0					0		0				
TRIZ (References[22] and[122])											0						0	0						
Usability studies (Reference[93])														0					0					
User personae (Reference[112])				0	0																			
Value analysis (References,[10],[90],[115] and[29])												0												
Value chain mapping (Reference[107])				0	0							0												
Value engineering (References,[10],[90],[115] and[29])												0		0										
Value stream mapping for lean processes (References[106] and[39])																				0				
V-Model of systems engineering (Reference[36])													0											
Warranty returns, complaints (Reference[91])						0			0													0	0	

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World class manufacturing (Reference[18])																0								

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A.2 Project goals table

Table A.2 — Project goals table

Goal statement	Description
Flexible design	Capable of being used on a variety of vehicle platforms/Low design risk.
Low BOM price	Cost reduced from current sensor. Cost not to be passed on to other areas of the system.
Technology leadership	Low error performance.
Low customer risk	No loss in performance due to component variation or all-out failure, “adequate redundancy”. No “Surprises” at SOP/Launch.

The project goals table helps the QFD team establish consensus about the project deliverables to the business. See Table A.2 and Reference [59].

EXAMPLE In the example, the first goal is flexible design and the benefit to the business is that it can be used on multiple vehicle platforms and lowers the design risk. This is done by the QFD team in conjunction with the project owner, typically a product manager. Often, these goal statements can be found in the project charter or similar document.

A.3 Project goals prioritization with AHP

Table A.3 — Project goals prioritization with AHP

	CS	AS	LL	PI	WR	Raw score	% of total
Customer satisfaction (CS)	1	5	10	5	10	31,0	40,5 %
Associate satisfaction (AS)	0,2	1	5	5	10	21,2	27,7 %
Landlord satisfaction (LL)	0,1	0,2	1	0,2	5	6,5	8,5 %
Profit improvement (PI)	0,2	0,2	5	1	10	16,4	21,4 %
Win and retain contracts (WR)	0,1	0,1	0,2	0,1	1	1,5	2,0 %
Totals	1,60	6,50	21,20	11,30	36,00	76,60	100,0 %

See Table A.3 and Reference [75]. When there are many project goals or when there is no consensus on which are driving the project, the goals may be prioritized using the analytic hierarchy process (AHP). AHP presents each goal in a pairwise comparison, the row compared to the column, by asking the evaluators (team and product manager), which is more important and by how much, based on a verbal scale. The verbal scale is

— extremely more important, represented by a 9 or 10,

— very important, represented by a 7,

— strongly more important, represented by a 5,

— moderately more important, represented by a 3, and

— equally important, represented by a 1.

When the row is more important, the integer is entered into the cell. When the column is more important, the fraction is entered.

EXAMPLE In this example for airport breakfast service, the upper left cell compares customer satisfaction (CS) to itself so a 1 is entered, meaning, they are equally important. The diagonal of the AHP decision matrix will always be 1s. The next cell to the right compares customer satisfaction (CS) to associate satisfaction (AS) and the QFD team has agreed that CS is strongly more important than AS, so they enter the integer 5. In the cell to the lower left, we see the same pair CS vs AS but now, CS is in the column, so the reciprocal 0,2 is entered in that cell. Generally, the cells to the lower left are reciprocals of the cells in the upper right, so they do not need to be queried twice. Thus, only the upper right pairs are queried. When there are four items, as in this example, that means only six pairs are queried.

Next, the scores are summed for each column and normalized (not shown). The normalized values are summed across and normalized again (called raw score in the example) and averaged to produce the % of total. The results are relative priorities of the project goals.

A.4 Scope boundary analysis

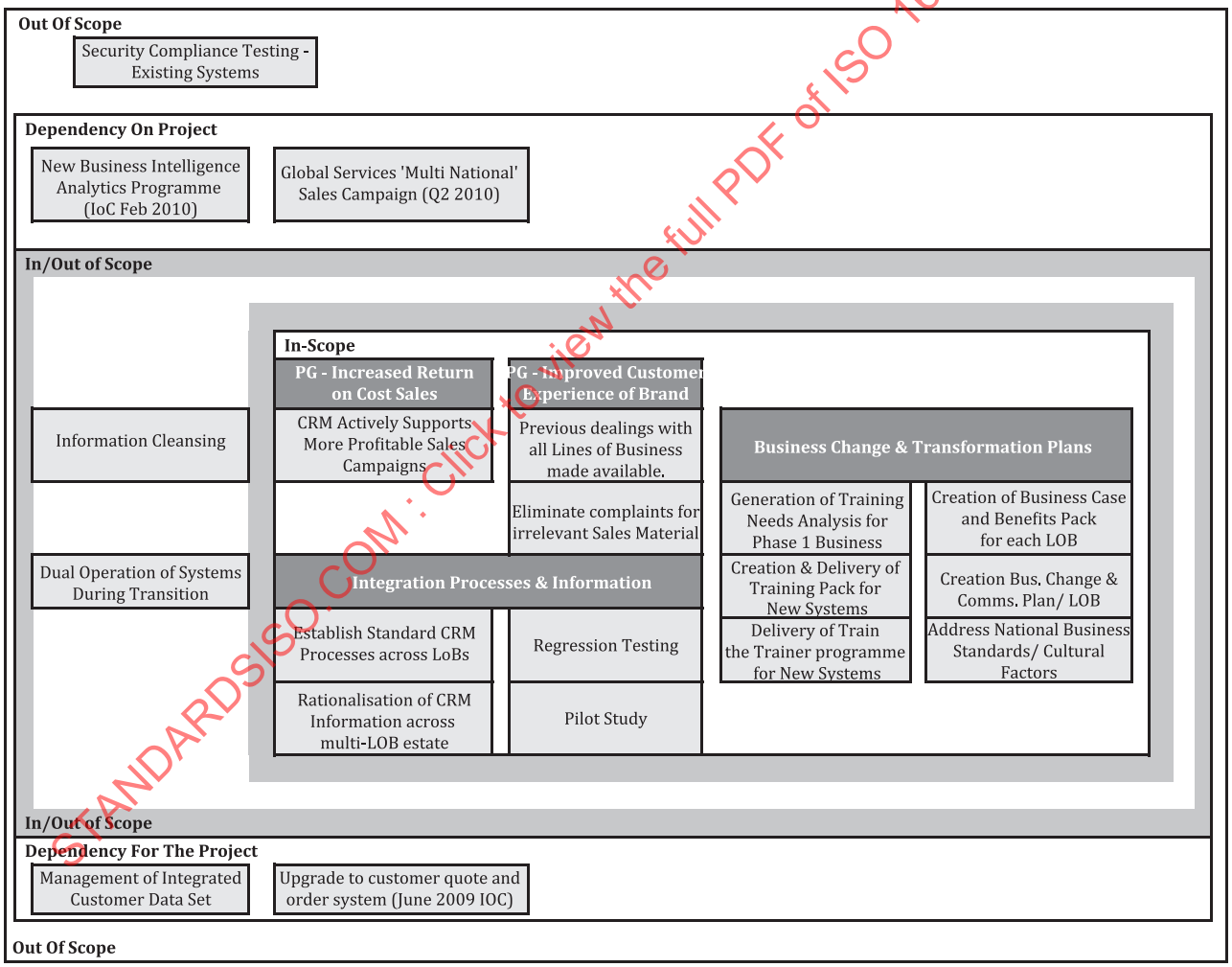

Figure A.1 — Scope boundary analysis

See Figure A.1 and Reference [120]. The QFD team and product manager can clearly define the scope of the project in order to prevent scope creep (expansion of the scope) or scope drift (changing

project goals). The scope boundaries can be displayed as what is in-scope, out-of-scope, not sure. Also, dependencies can indicate related concerns or tasks.

EXAMPLE In the example for customer management software, goals such as improved customer experience with brand in scope, while information cleansing, is out-of-scope.

A.5 Process beginning/end table

Table A.4 — Process beginning/end table

Begin	Process	End	Customers and stakeholders	Special requirements
Enter individual department reception	Consistently make patients feel like individuals	Discharged from department at door	Patients and family of lab, oncology, and DI	None

See Table A.4 and Reference [20]. Another tool for reaching consensus on project limits for service and process QFDs is this process beginning and end table.

EXAMPLE In this example, the hospital clinic will begin their investigation from the point where a patient enters the clinic until they are discharged out the clinic door. Additionally, other stakeholders interested in the performance of the process are identified so that results are limited to their experiences.

A.6 Customer segments table

Table A.5 — Customer segments table

Customer Segment	Who uses process	What morbidity or condition	What is process used for	Where	When	Why	How
Paediatric patient	Pt and family	spinabifida	improve interaction between visiting physicians	CMH main campus	daytime ambulatory clinic	visiting physicians do not have sufficient time to interact	develop new tools to better evaluate treatment options
Visiting physicians		mild traumatic brain injury				Share medical records from urban to rural facility members	Improve communication between physician and patient
Nursing Staff and Access Representatives		muscle and nerve					Improve communication among providers

See Table A.5 and Reference [39]. The customer segments table is used to clarify which customers and applications are most interesting for the QFD team to investigate first. Each customer segment is detailed in terms of who is using the product, service, process, application, and other characteristics, what is the product used for, where is it used, when is it used, why it is used, and how it is used (5W1H). Additional columns may be added according to the project. The 5W1H may also be used to specify the details of a customer visit to see certain activities or events.

EXAMPLE In this example of a paediatric clinic, the patient and family suffering from spinabifida are the subject of a new software application to improve the interactions between all the medical specialists treating the child for different maladies. These doctors come to the main medical campus at Children's Mercy Hospital (CMH) during the normal daytime clinic hours. The different doctors do not have sufficient time to confer about the patient and various treatment options. This situation is a key target for the QFD team to improve.

A.7 Project goals/Customer segments matrix

Table A.6 — Project goals/Customer segments matrix

Objectives	Objective weights	Customer segments						
		1	2	3	4	5	6	7
Tech reuse	0,041	●	○	○	●	Δ	●	Δ
Quality	0,127	Δ	○	●	○	○	Δ	●
Profit	0,131	Δ	Δ	●	Δ	●	Δ	●
Time 2 market	0,154	●	○	○	●	Δ	●	Δ
Brand	0,254	Δ	○	Δ	○	○	Δ	Δ
Market share	0,302	Δ	○	○	○	●	Δ	●
✓ Segment weights %		9	8	16	13	21	9	24
Δ = weak relationship of 1; ○ = moderate relationship of 3; ● = strong relationship of 9								

See Table A.6 and Reference [104]. When there are many customers to consider, it may be useful to prioritize them in order to assure that the most important customers are visited first. The prioritized project goals become the prioritization criteria and weights (called objectives in this example).

EXAMPLE In this mobile device example, seven customer segments are judged for their usefulness to achieving the goals. These judgments are weighted and cross-tabulated with the objective weights to yield segment weights. In this example, segments 5 and 7 are very useful to study in depth in order to achieve the most important objective of market share with 0,302 % or 30,2 % of the project goals. That drives these segments to be weighted at 21 % and 24 %, respectively. We could use these weights to allocate customer visit budgets (21 % of budget to visit customers in segment 5 and 24 % of budget to visit customers in segment 7).

A.8 Annotated customer process model

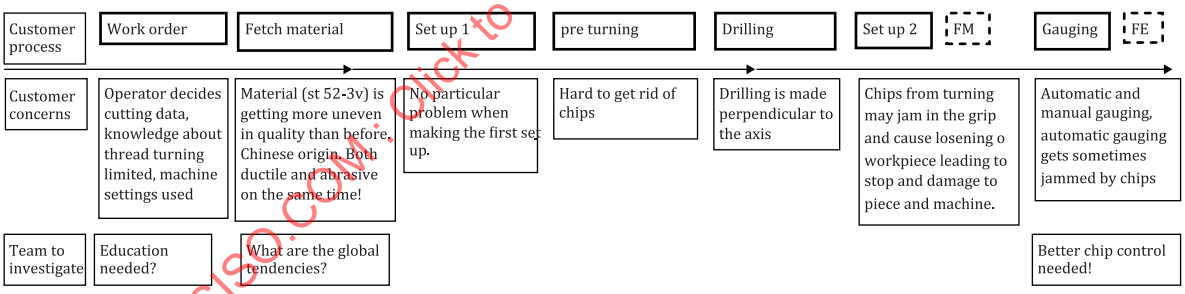

Figure A.2 — Annotated customer process model

See Figure A.2 and Reference [17]. The annotate customer model may be used to identify key steps or tasks that the customer does in their work or life. Annotations may include customer statements about likes and dislikes with each step, as well as areas to be investigated further.

EXAMPLE In this example of a machining process, process failure modes (FM) and failure effect (FE) have also been noted. This helps the QFD team see how a failure mode can be prevented or the effect mitigated.

A.9 Gemba visit table

Table A.7 — Gemba visit table

Interviewee:	John Doe			Interviewer(s):	Ted Hopwood
Contact info:	jdoe@abc.org			Date and Time:	30-Sep-03
				Place:	Historic Office - Bowling Green
Interviewee Characteristics (*memorable):					
Environment:	Discussion of sub-division owner feedback from community meeting.				
Process Step	Observations	Verbatims	Documents	Notes	Clarified Items *(with metrics)*
		Berms are 2'			Adequate sound barriers (reduce road noise so it does not disturb sleep) Adequate visual separation from road (cannot see into adjacent homes)
		Old pine trees will be relocated			"Country" view from lawn and windows maintained (degree of "surrounded by woods" unchanged) No unwanted views of activities on Lover's Lane (degree of "surrounded by woods" unchanged)
		Sub-division entrances will be eliminated			Ease of entry into sub-division (can identify where to turn in time) Easy to identify sub-division (sub-division name visible in time to turn) Exclusivity of sub-division maintained (design consistent with home architectures)

See Table A.7 and Reference [53]. More detail about customer process steps can be captured with observation of the customer "at work" in their gemba. The top portion of the table captures some of the details of the visit including when and where. Additional descriptions of environmental context may be noted. In the lower half of the table, key process steps, observational and verbatim data, as well as documents and team notes may be captured. The output of the table is to clarify and simplify complex data into single issue statements and measurements. This will improve the accuracy of prioritization later in the QFD because customers will be scoring discrete statements instead of compound statements.

EXAMPLE In this example on road construction, customer requests for two-foot berms are clarified as adequate sound barrier and visual separation from the road.

A.10 Customer voice table

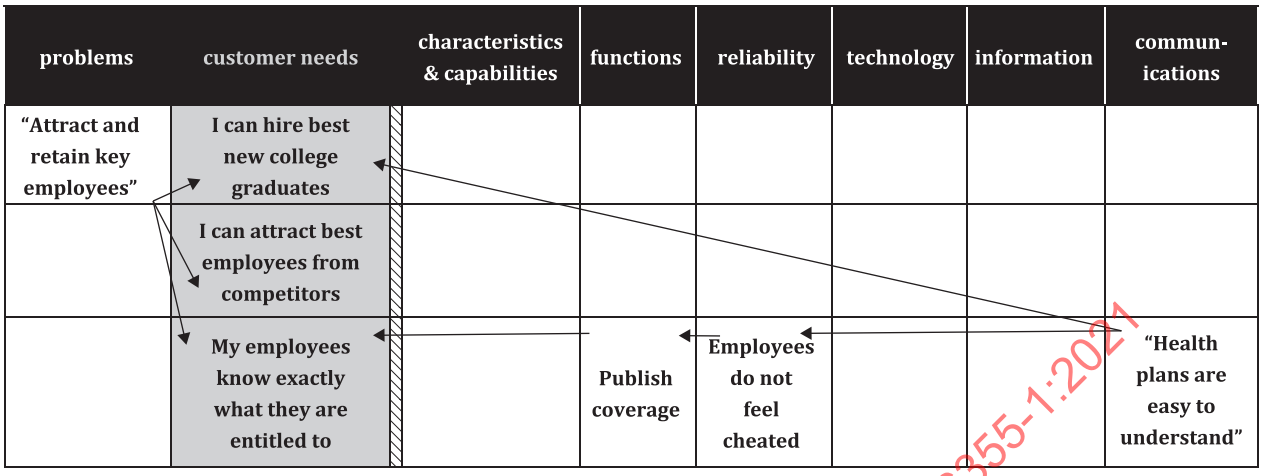

Figure A.3 — Customer voice table

See Figure A.3 and Reference [46]. The voice of the customer or stakeholder may include product requirements that should be translated into customer needs in order to explain why the customer wants them. This is important to understanding the benefit to the customer, which is key to the customer accepting the new product. It will also improve prioritization since the customer is more knowledgeable about their needs than our product features and can more accurately assess what is most important to them.

A customer need in QFD is the benefit to the customer of their problem solved, their opportunity enabled, or their image enhanced, independent of the product.

EXAMPLE In this health insurance example, the voice of customer is health plans are easy to understand. Understandability is a characteristic of the health plan and therefore a product requirement. In the analysis, the QFD team determined that this was related to a failure mode of employees feeling cheated when their company plan did not cover what they thought was covered according to the published documents that explained their insurance coverage. This leads to the customer need that employees know exactly what they are entitled to. This would also help the company hire the best new college graduates who were attracted to good health insurance.

A.11 Affinity diagram of customer needs

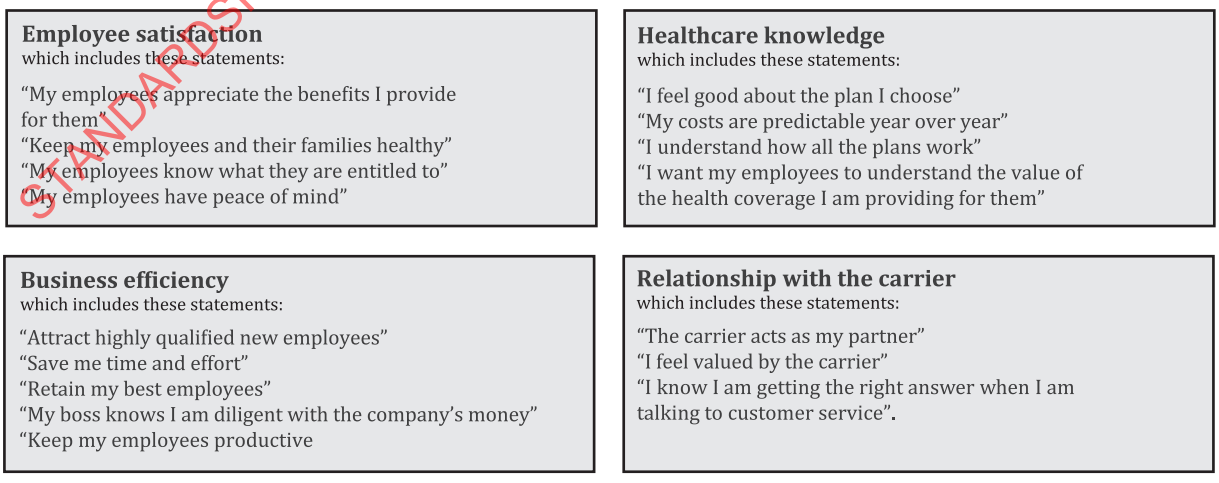

Figure A.4 — Affinity diagram of customer needs

See Figure A.4 and Reference [46]. When there are many customer needs, an affinity diagram may be used to manage them. The affinity diagram allows customers to group their needs in a way that makes sense to them. This helps find unspoken needs later in the hierarchy diagram that is used to analyse the affinity diagram. The customer needs affinity diagram is built using the KJ™ method developed by the Japanese anthropologist Kawakita Jiro (hence, the name KJ) following these steps:

a) write each customer need on a separate card;

b) have customers silently group the cards where they make most sense;

c) label each group of cards with a description of their common theme.

EXAMPLE In this health insurance example, the customer is the company employer offering health insurance plans to its employees. One group of customer needs such as "My employees appreciate the benefits I provide them" and "Keep my employees and their families healthy" are grouped with the label "Employee Satisfaction".

A.12 Hierarchy diagram of customer needs

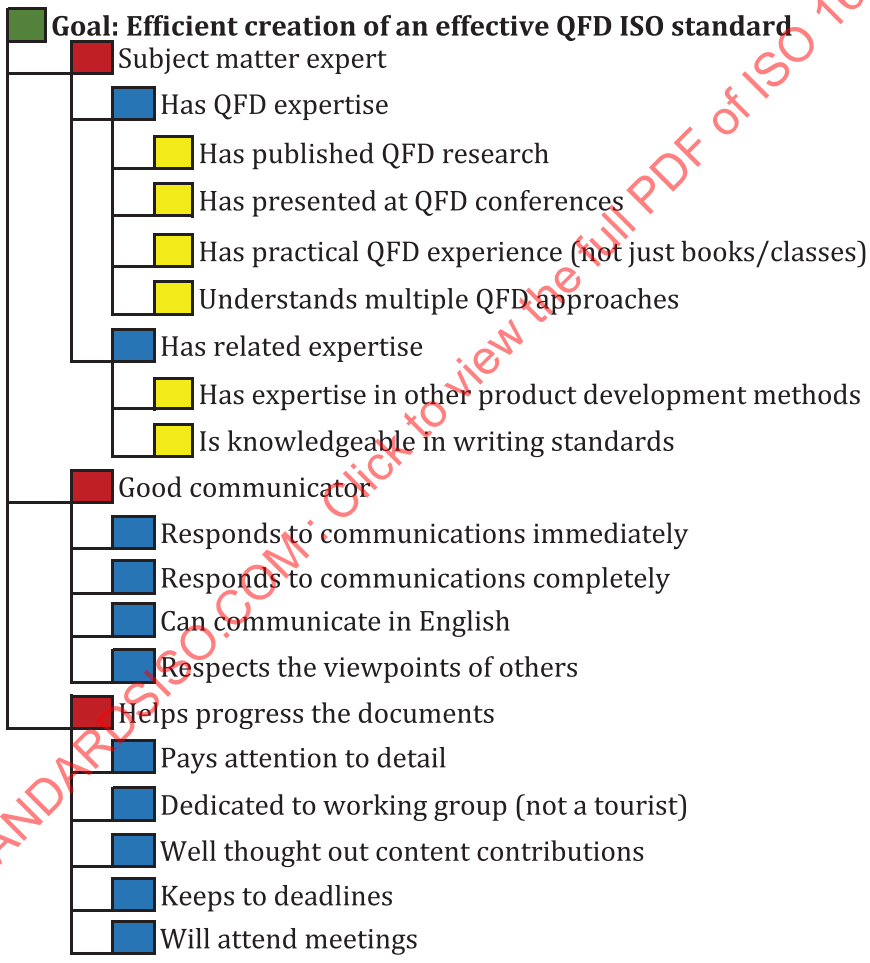

Figure A.5 — Hierarchy diagram of customer needs

See Figure A.5 and Reference [83]. The customer needs hierarchy diagram is used to address any structural issues with the customer needs affinity diagram. This is important for finding unspoken or missing customer needs, as well as improving the accuracy and efficiency of the prioritization process.

a) Rotate the affinity diagram counterclockwise 90°. This makes the following steps easier.

b) Starting from the left (called the primary level), confirm that the customer needs labels have the same level of abstraction.

c) Then determine if there are any missing needs at that level of abstraction that could be added.

d) Repeat at each level to the right for the secondary and tertiary levels.

EXAMPLE In the example from the QFD study to develop the ISO 16355 standard, there were three primary items of subject matter expert, good communicator, and helps progress the documents. To the secondary items under good communicator, responds to communications completely was added.

A.13 Customer needs prioritization with analytic hierarchy process

Public safety	Public is safe regardless of natural or man-made disasters.	Public is safe from attack on reactors.	Property is safe regardless of natural or man-made disasters.	Property is safe from attack on reactors.	normalized columns				sum	row avg
Public is safe regardless of natural or man-made disasters.	1	5	5	7	0,648	0,765	0,536	0,438	2,387	0,597
Public is safe from attack on reactors.	1/5	1	3	5	0,13	0,153	0,321	0,313	0,917	0,229
Property is safe regardless of natural or man-made disasters.	1/5	1/3	1	3	0,13	0,051	0,107	0,188	0,475	0,119
Property is safe from attack on reactors.	1/7	1/5	1/3	1	0,093	0,031	0,036	0,063	0,221	0,055
Totals	1,543	6,533	9,333	16	1	1	1	1	4	1
									Inconsistency Ratio	0,09

Figure A.6 — Customer needs prioritization with analytic hierarchy process

See Figure A.6 and Reference [125]. QFD asks the question "Are all customer needs equally important or are some more important than others?" If we just hand the customer a list of needs, they are likely to dismiss the question with "They are all important." This is not helpful to a product realization team that shall focus its limited resources. Classical QFD uses a five-point ordinal scale similar to a Likert scale so that customers can rate their needs. Ordinal scales do not have defined intervals and contain sufficient information only for modal counts or median calculation. Without defined intervals, other QFD mathematical operations such as addition, multiplication, division, and averaging have no meaning. Ratio scale priorities do permit these operations. Modern QFD uses the analytic hierarchy process (AHP) to derive ratio scale priorities by having customers choose between pairs of needs and determine which of the pairs is more important and by how much. Customers are encouraged to rate using a verbal scale (equally important, moderately more important, strongly more important, very strongly more important, and extremely more important) which then substitutes numbers (1, 3, 5, 7, 9, respectively) in a decision matrix. The eigenvector of the decision matrix closely approximates the relative priorities of the customer needs. AHP can also report when judgment inconsistency ($a > b$, $b > c$, $c > a$) is greater than the 10 % acceptable level. Responses from multiple customers can be averaged using the geometric mean, which is then entered into cells of the decision matrix. AHP can be applied to the customer needs hierarchy.

EXAMPLE In the example for corporate governance of a power utility, public is safe regardless of natural or man-made disasters is determined by the customer to be very strongly more important than property is safe from attack on reactors as indicated by the number 5 where the two needs intersect in the decision matrix. The eigenvector is then calculated by taking the row average of the normalized columns. The results show that for these four customer needs, public is safe regardless of natural or man-made disasters has a ratio scale relative importance of 59,7 %. Values displayed in the table are rounded to three decimal places.

A.14 Quality planning table (unweighted)

Key Customer Needs	Re-normalized priority	Customer evaluation of current product	Customer evaluation of Competitor	Positioning Plan	Competitive Improvement	Sales Point
	Need	Competitive Improvement				Claim
I want to know what fish is the freshest available	0,519	24 hrs after arrived at port	24 hrs after arrived at port	4 hrs after arrived at port	++	major
I want to know what are seasonal specialties	0,213	3 days from when fish appear	3 days from when fish appear	same day when fish appear	+	none
I know where the fish was caught	0,088	no	no	see on map	+	none
Product looks exactly like I expect	0,18	resembles catalog	resembles catalog	see actual picture	+	minor

Figure A.7 — Quality planning table (unweighted)

The quality planning table is used to capture customer perception of current and competitive product alternatives, propose an improvement target, and select potential selling points for later promotion. In classical QFD, these were scored with ordinal ratings but modern QFD can also accommodate more detailed information. Other types of information may be added. Since the effort to acquire competitive preferences may be great, it is recommended to begin with the highest priority customer needs. The quality planning may be weighted to adjust the customer need priorities. Ordinal ratings do not have defined intervals and so other QFD mathematical operations such as addition, multiplication, division, and averaging have no meaning.

NOTE Sometimes called the right-side room of the House of Quality, this table can also be used alone.

EXAMPLE In this example from a smart phone project, “I want to know what fish is the freshest available” had a high priority of 0,519. The current service and the competitive service can display this information after 24 h of arrival at port. The hoped-for level of service is planned at 4 h after arrival at port. This would give a competitive improvement of ++ or much better than the current alternatives. The sales and marketing members of the QFD team believe this could be a major selling point for the upgraded service.

A.15 Maximum value table

	Solution						Design	Implementation
Customer Need	Contract		Broker/Rep	Operations		Feedback		
	Benefits	Provider Network		Member Service	Claims			
My employees appreciate the benefits I provide to them.	Show savings to employee of using insurance	Explain to employees how Blue Card and BCBSF provider network is superior	Explain how benefits mechanism works			Assure benefits are working as promised and useful.	Employee Savings rpt Info	Expand PHR to include billing comparison to street rate
	Explain richness of benefits offered through BCBSF	Employee does not have to change "critical" MD (ped, 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 rpt Info	
							Report to summaryize 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	

Figure A.8 — Maximum value table

See Figure A.8 and Reference [46]. The maximum value table is a tool in modern QFD to quickly transform high priority customer needs into product features and assure their quality throughout the product realization process. The advantage of this table is that it can include inputs from every business activity necessary to design, develop, produce, commercialize, support, and even retire a product. Its efficiency is that it does this only for the highest priority customer needs as determined by the AHP. That is why accurate prioritization is important.

NOTE The columns of the table can be customized for each project.

In this health insurance example, the highest priority customer need is “My employees appreciate the benefits I provide to them.” To fulfil this need and assure that downstream service activities perform sufficiently, the following shall take place:

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

b) the 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) the system should collect user feedback to assure it works as promised;

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

A.16 Customer needs/functional requirements matrix (House of Quality) and other L-Matrices

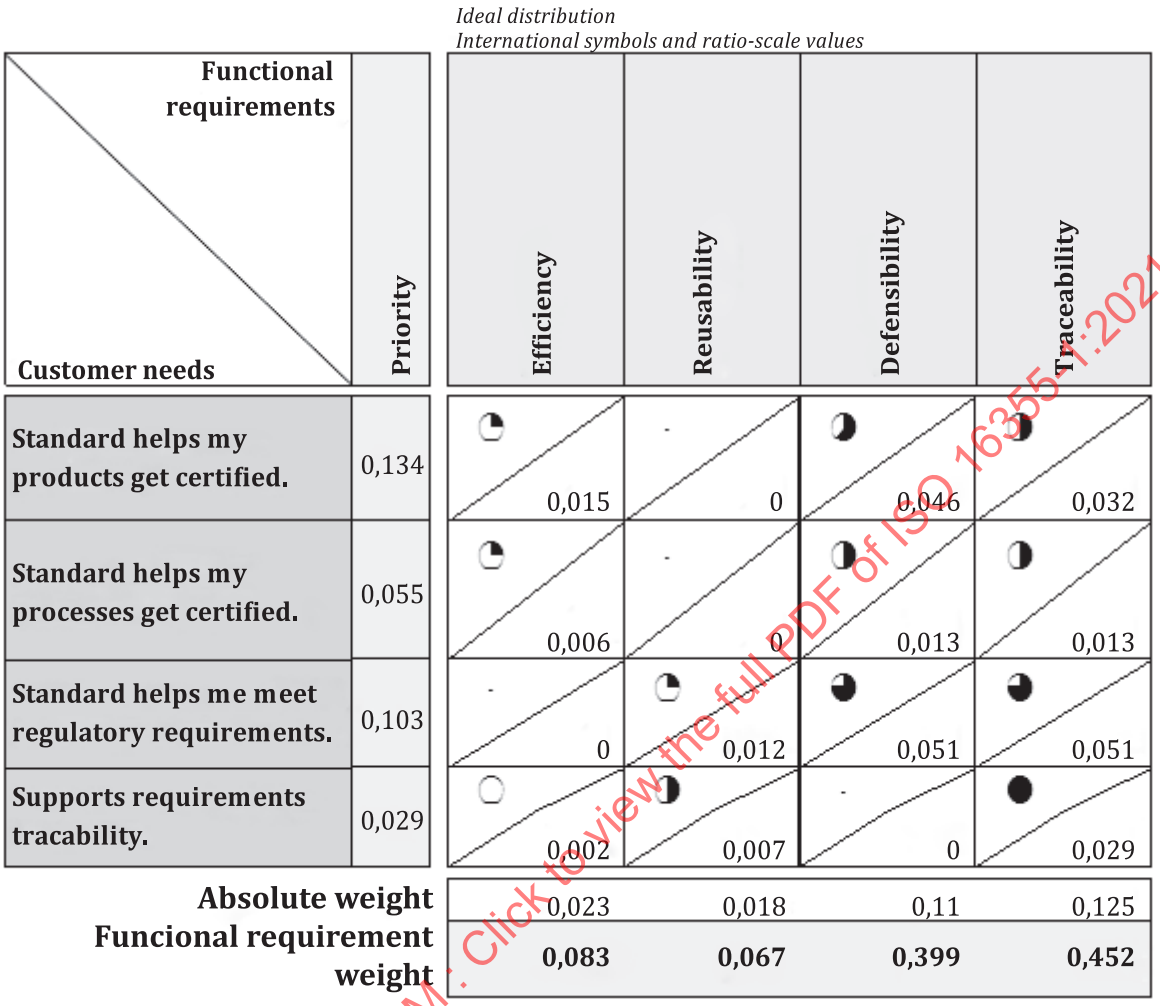

Figure A.9 — Customer needs/functional requirements matrix (House of Quality) and other L-Matrices

See Figure A.9 and Reference [83]. The customer needs/functional requirements matrix transforms the customer needs into functional requirements and customer need weights into functional requirement weights. The customer needs come from the hierarchy diagram and the weights from the AHP. Functional requirements describe what the product shall be or do without describing how it is to be done; they come from the members of the QFD team. Each need is then examined to determine if the functional requirement has a relationship, and if so, how strong is that relationship. The relationship strength can be expressed with icons or numbers.

NOTE 1 Modern QFD uses five or nine levels of relationships and ratio scale numbers. The priority of the customer need is multiplied by the relationship strength 1 (0,069), 3 (0,135), 5 (0,267), 7 (0,518), 9 (1,00), cell by cell and then summed column by column and normalized to calculate the functional requirement weight at the bottom. Values displayed in the table are rounded to three decimal places.

NOTE 2 Evaluating all customer needs throughout the entire product development process may require multiple L-matrices.

EXAMPLE In this example from the ISO 16355 development project, the customer need of standard helps my products get certified can be met strong-to-very-strongly by defensibility of the standard.

A.17 Design planning table

	Functional Requirements			Visibility of options	# Product varieties	# Topping varieties	# Heating options
				FR1	FR2	FR3	FR4
	Customer		Priority	29,7 %	38,2 %	22,8 %	9,3 %
information	technical evaluation	*Performance*	*current*	10 % display	2	3	0
			competitor	5 % menu	2	2	1
			target	60 % am display	6	5	1
	Relative to Competition		Judgment	Better	Better	Better	Equal
	Technical Challenge		Judgment	None	Minor	Minor	Major
	Technical Advantage		Judgment	None	Minor	Minor	Major
	Kano		Survey	Expected	Desired	Exciting	Expected

Figure A.10 — Design planning table

The design planning table is used to capture technical performance of current and competitive product alternatives, set an improvement target, and optionally determine the technical challenge and advantage of achieving the target. Since the effort to benchmark competitive performance may be great, it is recommended to begin with the highest priority functional requirements. The design planning may be weighted to adjust the functional requirement priorities. Ordinal ratings do not have defined intervals and so other QFD mathematical operations such as addition, multiplication, division, and averaging have no meaning.

NOTE Sometimes called the basement of the House of Quality, this table can also be used alone.

EXAMPLE In the example for airport breakfast service, the number of product varieties (the highest priority functional requirement) is only two items and the competitor offers only two as well. A target of six items is determined by the QFD team to be sufficient to be better than the competition, has only minor technical challenge, and offers a major technical advantage. A New Kano Model survey returns results that this would be a desired level of quality.

A.18 Super Pugh concept selection with AHP

criteria	% wt.	TC1 Slender	TC2 Solar	TC3 Pump	TC4 Head
power output (>15 watts)	53,9 %	15 34,1 18,4	8 18,2 9,8	9 20,5 11	12 27,3 14,7
weight (<70 grams)	28,2 %	100 28,9 8,2	90 32,2 9,1	230 12,6 3,6	110 26,3 7,4
risk of delay	9,3 %	↓ 41,6 3,9	↓↓↓↓ 5,6 0,5	↓↓↓ 11,1 1	↓ 41,6 3,9
acceptance by market	8,6 %	64,3 5,5	20,8 1,8	10,1 0,9	4,8 0,4
%		35,9	21,2	16,5	26,4

Σ count or estimate
Σ local priorities (%)
Σ global priorities (%)

priorities

Figure A.11 — Super Pugh concept selection with AHP

Selecting or prioritizing alternatives is a common step in new product realization. One instance of this is technology selection. The super Pugh method is a combination of Stuart Pugh's concept selection and AHP. Pugh originated his approach to help graduate students develop strong technical concepts to improve competitiveness. Pugh's approach displayed concept strengths and weaknesses against a datum in performance of unweighted technical criteria, allowing hybridization of concepts to achieve a stronger one. AHP strengthens this process by allowing weighting of the criteria and evaluating concept strengths and weaknesses with ratio scale counts or judgments.

EXAMPLE In the concept selection matrix of flashlights (torches), four prioritized (using AHP) selection criteria types are power output (ratio count where bigger is better), weight (ratio count where smaller is better), risk of project delay (absolute judgment), and acceptance by market (relative judgment). Each light is evaluated against each criterion and the score is normalized. For example, the slender light has a power output of 15 W, the solar 8 W, and so forth. The normalized scores are 34,1 % and 18,2 % respectively and are called local priorities. These scores are then multiplied by the criteria weights (53,9 % × 34,1 % = 18,4 %) and (53,9 % × 18,2 % = 9,8 %), respectively. These are called global priorities. Global priorities are summed by column (18,4 % + 8,2 % + 3,9 % + 5,5 % = 35,9 %) which indicates the relative strength of that technical concept. Values displayed in the table are rounded to one decimal place.

A.19 Kansei engineering for emotional quality

			Customer	Solution
Clarified items	#	customer scene	benefit need/image	product
Fast (I have one hour for lunch, and I walk 10 min from office) Easily available Good deal Fragrant Mild With work team Break from the usunal Light Authentic Special moments Romantic	1	Lunch time in London's central business district on a warm, sunny Monday. Mostly office workers in business or casual clothes, younger ones are single. Warm sunny day, in upstairs a la carte menu dining. Those in a hurry enjoying downstairs Buffet (6GBP), those with more time (business lunch, colleague birthday party) in upstairs a la carte menu dining. Most having soft drinks as it is too early in week for alcohol at lunch - Monday (first day of week).	**I want to have fun with my friends.** **I want something convenient.** **I enjoy the fragrance.** **I want to feel refreshed afterwards.** **I like to be adventurous.** **I want to spend my time the way I want.** **I'm in control.** **Authentic.** **Romantic.** **Special moments.** **A break from the ordinary.** **I'm a leader.** **I know what I like.**	Good deal. Fragrant food. Mild spices. Light meal.

Figure A.12 — Kansei engineering for emotional quality

See Figure A.12 and Reference [124]. Many products succeed as much on their emotional quality as their functional quality. Kansei engineering was developed by Michio Nagamachi in Japan to further explore the power of the sensory characteristics of a product.

EXAMPLE In this Singha beer example, customer narrations (VOC) were clarified and then translated into image- and sensory-related needs. These were later employed to develop a marketing campaign.

A.20 Reverse QFD

customer needs	characteristics & capabilities	functions	reliability	technology	information	commun-ications
I need help with appropriate physical activity.	member accountability for their physical activity			health club membership		
I need help with appropriate nutrition.	member accountability for their nutrition			diabetic nutrition education (Josylin)		
I need to know the progress of my condition.	diabetes progress reportability	patient self-reporting AIC		incent patient A1C reduction		
I need up-to-date information on my condition.				provide free testing supplies for 3 months		

Figure A.13 — Reverse QFD

See Figure A.13 and Reference [52]. While many QFD projects are customer-driven, there are projects that are technology-driven, regulatory driven, cost-driven, or driven by other imperatives. These projects may find reverse QFD helpful. Reverse QFD begins with the driver of the change and works in reverse to discover the effects on customer needs.

EXAMPLE In this health insurance project, technology solutions were offered by employees and reverse QFD was used to discover if the needs the solutions could address had a high priority. For example, offering health club memberships would have the characteristic of making members accountable for their own physical activity which could address the customer need of "I need help with appropriate physical activity." If this need was highly prioritized by customers, then the insurance company would offer it.

A.21 New 7 management and planning tools

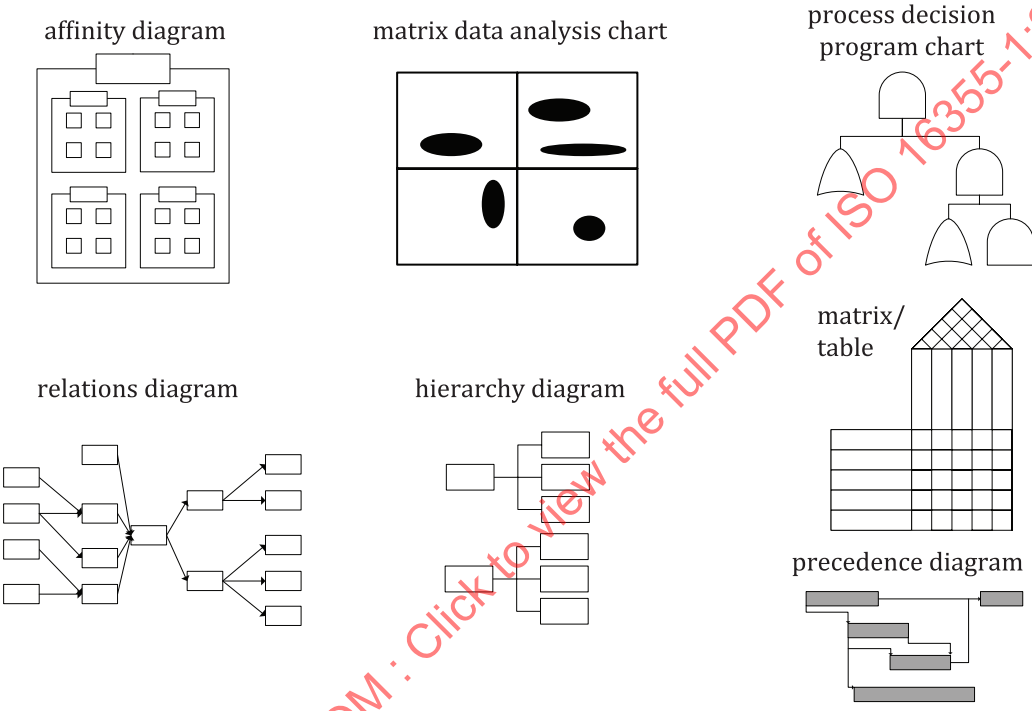

Figure A.14 — New 7 management and planning tools

Due to the subjective and verbal nature of customer needs, a qualitative tool set was assembled by QFD cofounder Shigeru Mizuno and Yoshinobu Nayatani to help manage the data. These tools are used extensively throughout the QFD process to acquire, sort, analyse, prioritize, and transfer qualitative information. Modern QFD has added additional tools such as AHP and failure mode and effects analysis (FMEA).