Transitioning from JIS Q 9025 to ISO 16355

Glenn H. Mazur, QFD Red Belt®

QFD Institute
1140 Morehead Ct.
Ann Arbor MI USA
+1 734-995-0847
glenn@mazur.net

ABSTRACT

The new ISO 16355 standard for QFD is now published in 2017. It is a “framework” based on Yoji Akao’s Comprehensive QFD model and includes guidance in its application to manufacturing, service, and IT products. While this is the first International Standard, Japanese companies have been guided by the JIS Q 9025 standard since 2003. This paper, by the Convenor of the ISO Working Group that wrote ISO 16355, will discuss the similarities and differences between the ISO and JIS standard, why it is important to update QFD best practice to this new global level, and how to make the transition. The paper will include cross-references between the JIS and ISO clauses as well as examples of new tools and methods from around the world that make ISO 16355 the strongest QFD model to follow. It is applicable to assembled and processed products, services, and information products in both business-to-business (B2B) and business-to-consumer (B2C) environments.

KEYWORDS

QFD, ISO 16355, JIS Q 9025, Voice of customer, Voice of stakeholder

1. INTRODUCTION

In 2008, the Japanese Standards Association, on behalf of Dr. Hiroe Tsubaki of the Research Analysis Center of The Institute of Statistical Mathematics and a professor of the Graduate School of Business at the University of Tsukuba in Tokyo, along with professor Tadashi Ohfuji of the School of Business at Tamagawa University in Tokyo proposed an international standard for quality function deployment (QFD) be drafted. [1] The author was recommended to convene a working group to write this draft under the

> International Standards Organization Technical Committee 69, Applications of statistical methods

>> Subcommittee SC 8, Application of statistical and related methodology for new technology and product development

>>> Working Group WG2, Transformation.

The project began in 2010 and subject matter experts were solicited from the International Council for QFD. [2] The experts quickly drafted an outline of the standard into eight parts to include collaboration with the other two SC8 working groups: WG1 on selection of value from voice of customer or society and WG3 on optimization of performance. The standard is established as "descriptive" guidance rather than "prescriptive" requirements that "shall be" met. It is designed to be used both by business enterprises trying to use the voice of customer (VOC) to define new products and societal or governmental organizations trying to use the voice of the stakeholder (VOS) to define their services.

The eight parts of the standard are now available at https://www.iso.org/committee/585031/x/catalogue/:

— Part 1: General Principle and Perspective of QFD Method (ISO 16355-1:2015) [3]

— Part 2: Acquisition of Non-quantitative VOC or VOS (ISO 16355-2:2017) [4]

— Part 3: Acquisition of Quantitative VOC or VOS (ISO/NP 16355-3)

— Part 4: Analysis of Non-Quantitative and Quantitative VOC/VOS (ISO 16355-4:2017) [5]

— Part 5: Solution Strategy (ISO 16355-5:2017) [6]

— Part 6: QFD-related approaches to optimization (ISO/NP 16355-6)

— Part 7: Other approaches to optimization (ISO/NP 16355-7)

— Part 8: Guidelines for commercialization and life cycle (ISO/TR 16355-8:2017). [7]

2. CRITICAL FEATURES OF ISO 16355 THAT AUGMENT JIS Q 9025

2.1 General Principle and Perspective of QFD Method (ISO 16355-1:2015)

Part 1 of the standard outlines the general principles and various "voices" of QFD, as well as methods and tools that have been used since QFD began in the 1960s in Japan. These "voices" include voice of business, voice of customer/stakeholder, and voice of engineering and operations. To analyze and act on these "voices," various methods and tools are introduced to structure, prioritize, quantify, and deploy into quality, technology, cost, reliability, safety, and security concerns at the product level, system level, subsystem level, component level, and process level. These are then deployed to build, logistics, technical support, and retirement from the market. Examples and case studies for many of the methods and tools are included in the Annex. Each of the methods and tools is supported by a published paper or book available in English. [8]

Part 1 recommends what types of projects where QFD would be most helpful, such as manufactured, service, or technology products, as well as adaptations for business-to-business (B2B) and business-to-consumer (B2C) focus. Also recommended are which organization functions should participate as leader, permanent team members, and invited subject matter experts.

Different QFD models are diagrammed including Yoji Akao's Comprehensive QFD [9] [10] which includes the U.S. 4-Phase model, [11] the QFD Institute's modern Blitz QFD® [12], and the German QFD Institute best practices flow [13] as shown in Figure 1. The three models overlap in several areas such as the quality table (House of Quality), technology development, reliability, and cost analyses. The Japanese Industrial Standard JIS Q 9025:2003 is based on the Comprehensive QFD model. [14] The Blitz QFD® model has additional tools to connect the project to a wider product development strategy using *hoshin kanri* or policy deployment, as well as tools to acquire and analyze the voice of the customer and translate into true customer needs. The ISO 16355-1:2015 flowchart shown in Figure 2 outlines the methods and tools in all three models and includes guidance and examples.

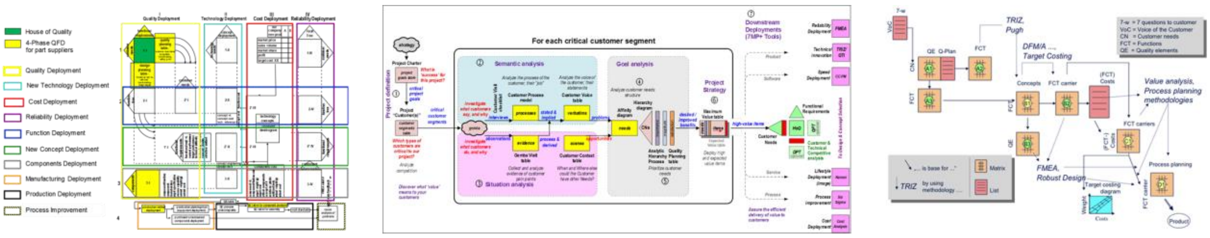

Figure 1 Comprehensive QFD/JIS Q 9025, modern Blitz QFD®, and German QFD models

Clause 13 on transfer of prioritization introduces the use of the analytic hierarchy process (AHP) to quantify both customer needs and relationship weights. While this is introduced on page 109 of Akao's 1988 book [10] based on the work of Saaty [15] and Tone [16], it is not included in the JIS Q 9025:2003. Since transfer of prioritization is a critical part of QFD, the improved accuracy of using ratio scale values derived with AHP will be helpful. This is because the ordinal scale numbers (1-5 for customer need weights, and 1-3-5 for relationship values for Weak △ Moderate ○ Strong ◎ indicated in JIS Q 9025:2003, Annex 6 Table 1, do not have equality of ratio between the values and so should not be used for the addition, multiplication, and division math when performing the independent rating calculations in the quality table or house of quality. The more precise AHP derived ratio scale values are Weak (0.059), W-M (0.079), Moderate (0.112), M-S (0.162), Strong (0.237), S-V (0.344), Very strong (0.498), V-X (0.712), eXtremely strong (1.000). Thus, the ratio scale relationship values are expanded to either 5 or 9 levels to increase the accuracy of human decision making, and an international symbol set is recommended as shown in Figure 3.

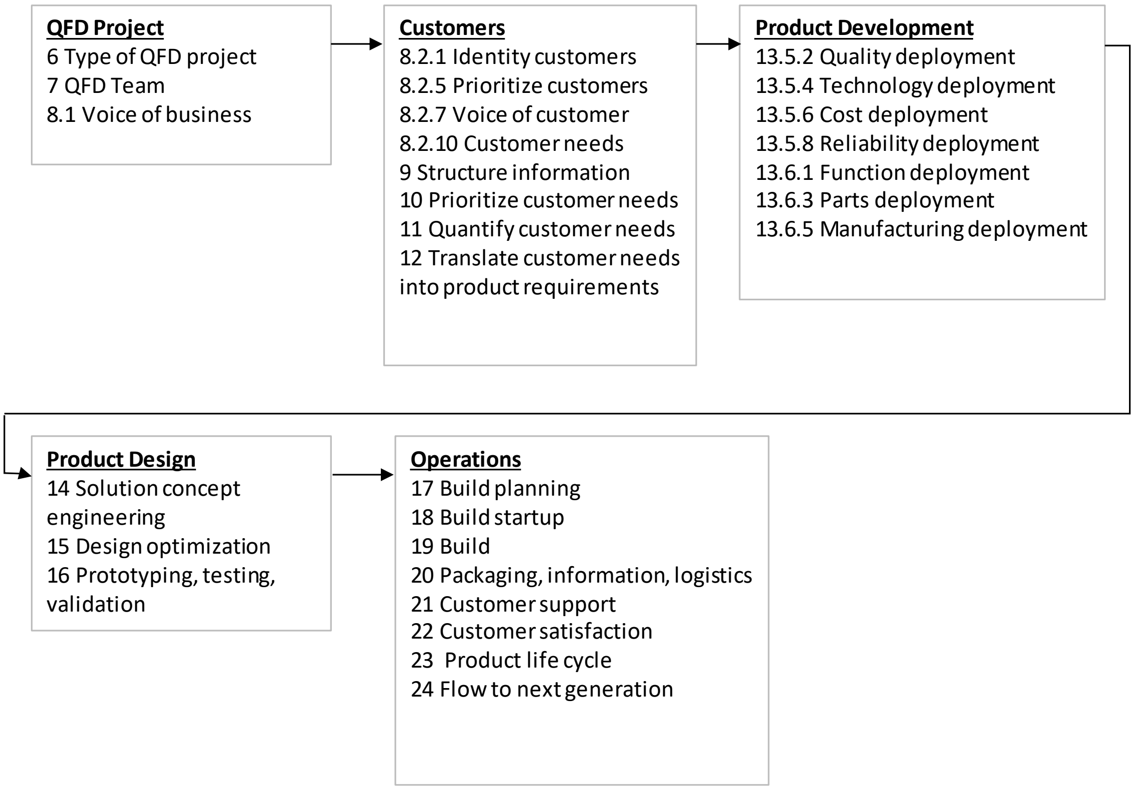

Figure 2 ISO 16355-1:2015 flowchart of clauses

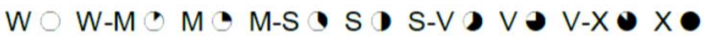

Figure 3 International symbols for QFD matrices

2.2 Acquisition of Non-quantitative VOC or VOS (ISO 16355-2:2017)

Following the modern Blitz QFD® model in part 1 of the standard, part 2 begins by defining strategic plans that help the organization prioritize which projects will received the necessary funding and resources. It continues with identifying key customer segments and various ways to capture the spoken and unspoken voice of the customer and stakeholder. This is shown in the flowchart in Figure 4.

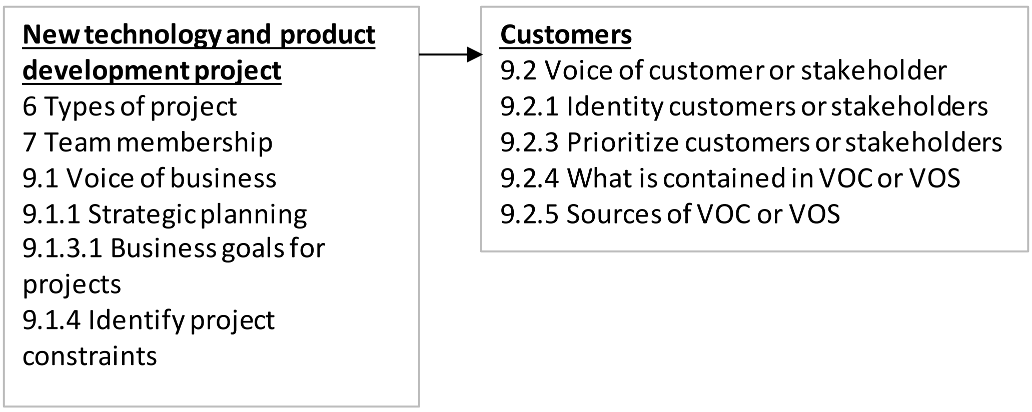

Figure 4 ISO 16355-2:2017 flowchart of clauses

Voice of customer analysis has become extremely important in modern QFD. In the classical QFD models such as Comprehensive QFD, the focus was on design and build quality more than customer quality. The shift in recent years from product quality to customer quality is exemplified by Mitsubishi Heavy Industries (MHI), the first company to publish its use of the quality table (house of quality) in 1972. [17] In 2016, MHI suffered a tremendous loss building luxury cruise liners for Carnival Cruises. The president of MHI admitted that despite their past reputation as a ship-builder, they were not able to adequately understand fuzzy customer needs for ship-wide Wi-Fi, air conditioning, and other technology areas, and this resulted in extreme delays and cost overruns. [18] The losses were almost double the revenue potential. Thus, any modern organization using QFD must begin upstream from the House of Quality, with an in-depth analysis of the voice of the business and the voice of the customer.

The starting point of the voice of the business is strategic planning using *hoshin kanri* to define vision, mission, and short-term objectives, and if the means to achieve the objectives requires new markets or products, what specifics goals the QFD project must deliver. Detailed guidance and examples are included. [19] The *hoshin kanri* section bridges from the JIS Q 9023:2003 [20] and the JSQC-Std 33-001:2016 [21] to introduce several methods and tools to help an organization identify and prioritize new product development project opportunities. The following methods and tools with examples of their use in the development of a new product development hoshin project are in the following clauses of ISO 16355-2:2017.

9.1.2.3 Porter five force competitive analysis, to understand competitive opportunities and threats;

9.1.2.4 Kotler's market portfolio planning, to understand product, price, place, and promotion;

9.1.2.5 Blue Ocean Strategy, to identify uncontested market opportunities;

9.1.2.6 New Lanchester strategy for sales and marketing, to identify competitive threats and targets in order to grow market share;

9.1.2.7.2 Balanced scorecard, to monitor the effectiveness of the strategy;

9.1.2.8 Project prioritization and selection using the analytic hierarchy process (AHP), to focus on projects that will achieve the strategy.

Once the QFD projects are prioritized according to their business impact, the next step is to assure the project charter includes the following, as detailed in these ISO 16355-2:2017 clauses.

9.1.3 Business goals for projects, to clarify the business success criteria of the project;

9.1.5 Project scope analysis, to clearly define the boundaries of the project and prevent scope drift and scope creep.

Non-quantitative or qualitative voice of customer acquisition is done through both a semantic (verbal) and situation (observational) analysis of the language and behavior of targeted customer segments, as shown in the modern Blitz QFD® model. Customer segments are defined by use cases or applications, which can then be prioritized based on the business goals. The basic methods and tools were systematized in 1990 by Ohfuji, Ono, and Akao [22] and later incorporated into modern Blitz QFD®. [12] Additional methods and tools used by global marketers and product developers are explained in these ISO 16355-2:2017 clauses.

9.2.1.2 Customer value chain, to identify the various intermediate customers between the producer and the consumer who may have unique requirements;

9.2.1.3 User personas, to aggregate different customer attributes into a fictional profile that developers can focus on;

9.2.1.4 Stakeholder analysis, to map the relationships among all interested parties in complex technical products;

9.2.2.2 Customer segments table, to clearly define use cases and customer applications based on who, what, when, where, why, and how of use (5W1H);

9.2.3 Prioritize customers or stakeholders, to focus limited customer interactions on customer who best help the project succeed;

9.2.5 Sources of VOC or VOS, to identify a variety of customer or stakeholder inputs that can be examined through various methods and tools; these include

9.2.5.2 Customer gemba visits, to visit customers in situ (gemba) at their work or life activities;

9.2.5.2.3 Customer process model, to map the customer process and identify things gone right and things gone wrong in it;

9.2.5.2.4 Gemba visit table, to directly observe or even participate in critical customer activities;

9.2.5.3 Customer-supplied specifications; often given on drawings or in requirements documents;

9.2.5.4 Customer support and help systems, where pre- and after-sales support staff can capture customer inputs;

9.2.5.5 Analysis of beliefs (AoB), to understand cultural nuances and intrinsic idiosyncrasies;

9.2.5.6 Focus groups, to gather customers or stakeholders with similar attributes to discuss both concerns as well as to assess possible solutions;

9.2.5.7 Social media, to capture on-line communities and individual preferences;

9.2.5.8 Free response questionnaires, to capture customer stream-of-conscious thoughts;

9.2.5.9 Interviews (direct and secret shopper), to structure responses to specific questions;

9.2.5.10 Customer satisfaction surveys, to understand alternative products and their degree of satisfaction;

9.2.5.11 Lead user analysis, to involve key opinion leaders in the design of new products;

9.2.5.13 Sales, maintenance, and technical visit reports, to bring after-sales and service feedback into the next generation products;

9.2.5.14 Ethnographies, to employ anthropological and sociological studies to better understand customer motivation;

9.2.5.15 Continuous QFD and collaborative QFD, to map communications among interdisciplinary groups both within and between customers and developers;

9.2.5.16 Design thinking, to employ iterative design cycles to improve products;

9.2.5.17 Conference papers, reports and journals, to capture leading-edge research in marketing and technical areas;

9.2.5.18 Gender mainstreaming, to better identify expectations associated with different genders.

2.3 Acquisition of quantitative VOC or VOS (ISO/NP 16355-3)

As a subcommittee of ISO Technical Committee 69, Applications of statistical methods, ISO 16355-3 includes ways to quantify the voice of customer and stakeholder that add analytic strength to the Comprehensive QFD, JIS Q 9025, 4-Phase, Blitz QFD®, and the German QFD-ID models. Many quantitative methods have been used at the front end and throughout the classical QFD process to improve the understanding of the voice of the customer and stakeholder as well as to address technical requirements and solutions of the subject product. In recent years, other quantitative methods and tools have been integrated. While still in draft form, part 3 of the standard includes detailed guidance on survey questionnaires and how to design, build, collect, process, disseminate, archive, and evaluate them, as well as several methods and tools, including case studies, which have been used in conjunction with QFD to quantify VOC and VOS, as shown in Table 1. Alternative methods and tools may be used according to the information needs of the QFD project team, so the flow is based on the new product development process.

Table 1 Acquisition of quantitative VOC or VOS – tools and methods

New product development phase	Method or tool	ISO clauses
8.1 Market strategy and trends	Analytic network process (ANP)	ISO 16355-3, 9.1
	Porter 5 force competitive analysis	ISO 16355-2:2017, 9.1.2.3
	Market position analysis	ISO 16355-3, 9.7
	Project selection	ISO 16355-2:2017, 9.1.2.8
8.2 Market segments	Demographics using cross tabulation	ISO 16355-3, 9.8
	Attitudinal and cultural dimensions	ISO 16355-3, 9.5
	New Kano model	ISO 16355-5:2017, 10.3.4.4.8.1
	Repertory grid technique	ISO 16355-3, 9.14
8.3 Competitive space	Benchmarking	ISO 16355-4:2017, 12.2

New product development phase	Method or tool	ISO clauses
	Market position analysis	ISO 16355-3, 9.7
	Multidimensional scaling (MDS)	ISO 16355-3, 9.9
	Repertory grid technique	ISO 16355-3, 9.14
8.4 Customer and stakeholder applications	Frequency of use or application	ISO 16355-3, 9.8
	Robust parameter design	ISO 16355-6 / ISO 16336:2014
8.5Customer needs	Functional needs using text analytics	ISO 16355-3, 9.15
	Emotional or attractive needs using kansei engineering	ISO/TR 16355-8:2017, 8
8.6 Prioritization	Analytic hierarchy process (AHP)	ISO 16355-2:2017, 9.1.2.8, 9.1.3
	L-matrices	ISO 16355-2:2017, 9.2.3
	Cluster analysis	ISO 16355-3, 9.4
	Analytic network process (ANP)	ISO 16355-3, 9.1
	Benchmarking	ISO 16355-4:2017, 12.2
8.7 Product requirements, feature sets, concept options	Conjoint analysis	ISO 16355-3, 9.3
	House of quality	ISO 16355-5:2017, 9.3.6
	Quantification method III	ISO 16355-3, 9.12.1
	Regression analysis	ISO 16355-3, 9.13
	Repertory grid technique	ISO 16355-3, 9.14
	Text analytics	ISO 16355-3, 9.15
8.8 Distribution, logistics and inventory, sales channels	New Lanchester strategy	ISO 16355-2:2017, 9.1.2.6
8.9 Customer satisfaction surveys and preference benchmarking	Customer satisfaction surveys	ISO 10004:2012, ISO 16355-3, Annex A
	Fuzzy set theory	ISO 16355-3, 9.6
	Net promoter score (NPS)	ISO 16355-3, 9.10
	Neural networks/artificial intelligence	ISO 16355-3, 9.11, 9.2
	Regression analysis	ISO 16355-3, 9.13

2.4 Analysis of Non-quantitative and Quantitative VOC/VOS (ISO 16355-4:2017)

In classical QFD models, there was an assumption that the customer supplied an accurate and complete set of requirements, and the product designer would then transfer these into functions and specifications which were deployed into downstream quality requirements. As QFD applications broadened in the service and software sectors and as products became more complex with rapidly changing technology, this assumption was no longer true. Global competition in these new technologies have elevated the role of new product development, and thus QFD, above just quality assurance of the design and build, to include quality of upstream market research and understanding of customer use cases and applications as well as quality of downstream product launch, security, support, maintenance, and even retirement from the market.

The quality of the market research was improved through the various non-quantitative and quantitative methods and tools mentioned in ISO 16355-2:2017 and ISO/NP 16355-3. Part 4 of the standard takes this research as an input to a deeper analysis that seeks out *true* customer needs that may be revealed (extrinsic) or unspoken (intrinsic) by the customer through their language and behavior, as shown in the flowchart in Figure 4.

Customers and Stakeholders
9.1.1 Benefits of VOC/VOS analysis
9.1.2 Sources of VOC/VOS
9.1.3 Information types in VOC/VOS
9.2 Translating VOC/VOS int customer needs
10 Structuring information sets
11 Prioritizing customer needs
12 Quantifying customer needs

Figure 5 ISO 16355-4:2017 flowchart of clauses

This analysis is based on the "raw data transformation sheets" (原始データ変換シート) presented by Ohfuji, Ono, and Akao in 1990. [22] This sheet was renamed "customer voice table" in modern Blitz QFD® because it identifies any kind of customer or stakeholder narrative or behavior and translates it into a customer need. ISO 16355-1:2015, 3.3 defines a customer need as a statement of potential benefit to the customer of their problem solved, their opportunity enabled, or their image enhanced, *independent* of the product, its functions and specifications, or features. The mechanics of the table are similar to an Ishikawa fishbone diagram, where the "voice" is a "bone" and the "need" is the head. Each customer voice is then examined to determine that if it were fulfilled, what would be the resulting benefit to the customer. In this way, *true* customer needs can be extracted from the VOC and VOS.

Once customer and stakeholder needs are extracted, they can be structured, prioritized, and quantified. The structuring process asks the targeted customers to group and super-group their needs into an affinity diagram based on how they see similar themes in the need statements. The hierarchy diagram is used to align the levels of abstraction of the affinity diagram groups and to add any missing needs. For prioritization, the early classical QFD models used ordinal scale numbers to determine level of importance, but as stated above, accuracy has been improved by changing to ratio scale numbers using the analytic hierarchy process (AHP). [10]

ISO 16355-4:2017 concludes by updating the quality planning table where customer perception of competitive alternatives are benchmarked, a customer satisfaction plan is set, and selling points are identified. Two updates are included: the first is an unweighted quality planning table used in modern Blitz QFD® to benchmark alternatives using customer-provided measurements instead of ordinal scale ratings; the second update is to use ratio scale ratings with AHP.

2.5 Solution Strategy (ISO 16355-5:2017)

While parts 1, 2, 3, and 4 are partially included in JIS Q 9025, part 5 of the ISO 16355 standard aligns more closely in that it follows the Comprehensive QFD structure of quality deployment, technology deployment, cost deployment, and reliability deployment at the product level, system level, and subsystem level, as shown in Figure 7. Component and process levels are detailed in part 8 (ISO/TR 16355-8:2017). A cross reference between JIS Q 9025 and the ISO 16355 clauses is included in Annex 1. ISO 16355 clauses that are not in JIS Q 9025 are explained in this paper.

2.5.1 Maximum Value Table

Part 5 provides guidance on the maximum value table (MVT) used in modern Blitz QFD®. The MVT is a simple table used to fully deploy only the highest priority customer needs, one at a time, throughout the entire design, develop, build, commercialize, support, and retire phases. It contains only extremely strongly related product details to assure the quality of technical and operational activities. The MVT may be used alone in some projects, or can precede the classical Comprehensive QFD matrices to give developers a faster start on what will emerge in the later matrices as the highest priority quality requirements. The MVT is shown at the right side of Figure 6, following the strategy and voice of customer analyses in ISO 16355 parts 2, 3, and 4.

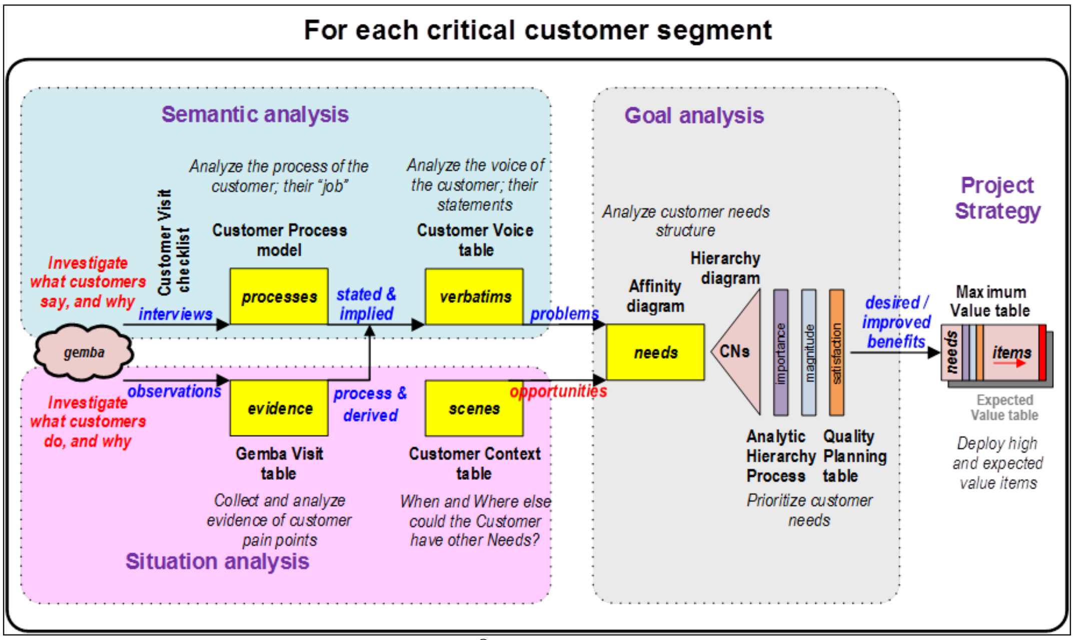

Figure 6 Modern Blitz QFD® flowchart with maximum value table

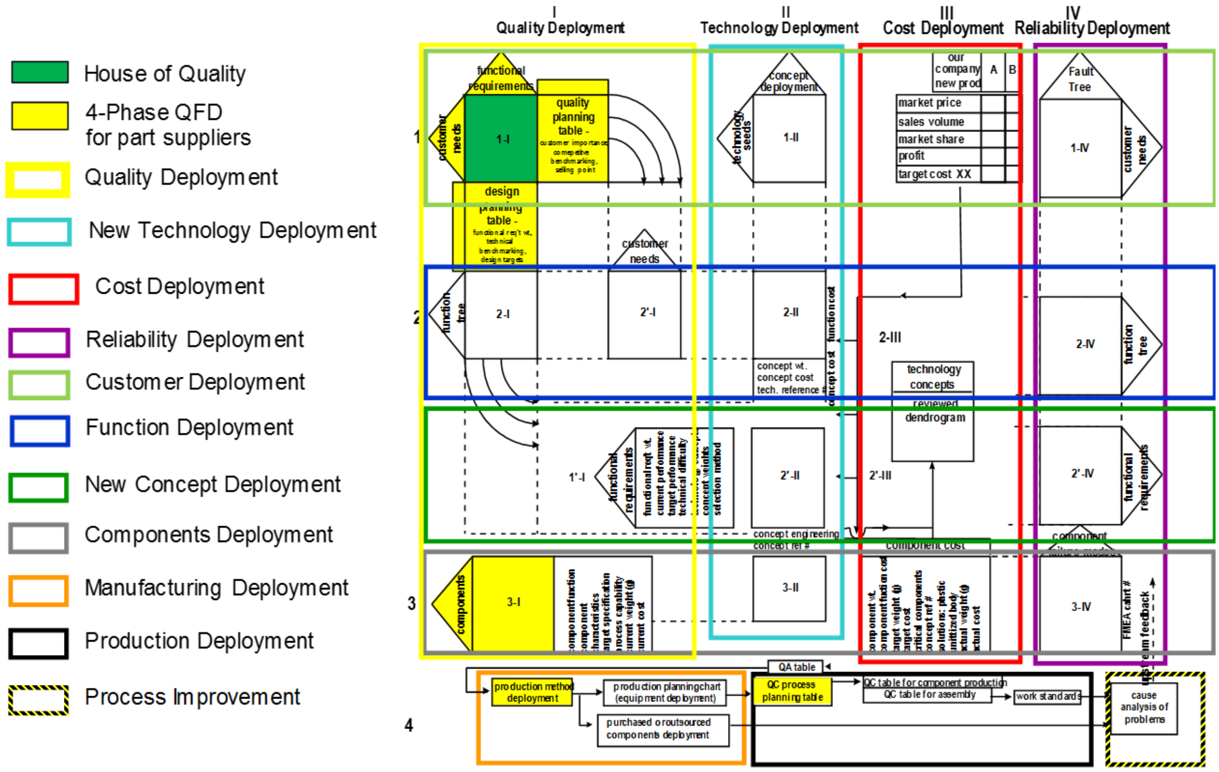

Figure 7 Comprehensive QFD flowchart used in ISO 16355-5:2017, ISO/TR 16355-8:2017, and JIS Q 9025:2003

2.5.2 Quality Deployment

ISO 16355-5:2017 follows the Comprehensive QFD and JIS Q 9025:2003, 6.2 matrix flow of customer needs – functional requirements (called quality characteristics in JIS) matrix (house of quality table, ISO 16355-5:2017, 10.4.2.2) and functional requirements – function matrix (ISO 16355-5:2017, 10.4.2.4) at the design level. One additional analysis, the customer needs – function matrix (ISO 16355-5:2017, 10.4.2.3) is included in the Comprehensive QFD and ISO but is omitted in the JIS Q 9025:2003, 6.2. The quality assurance table and quality control process table appear later in ISO/TR 16355-8:2017, 9.9 and 13.5.1 respectively, after the optimization steps of ISO 16355-6 and ISO 16355-7. Also, more precise ratio scale values and more relationship levels and symbols are integrated into the matrices, as shown above in section 2.1 and Figure 3 or this report.

Quality deployment also includes quantification of the functional requirements using the design planning table in ISO 16355-5:2017, 10.3.4 which is only briefly covered in JIS Q 9025:2003, 5.4.2. The ISO version includes both an unweighted and a weighted analysis of adjustment factors such as competitive technical benchmarking, technical challenge, technical advantage, and links to the Kano model surveys [23] for attractive quality creation which is detailed with guidance and examples.

2.5.3 Technology Deployment

Technology deployment is used to assess the readiness of solutions to enable functional requirements, either to fit existing solutions to the requirements (called seeds-to-needs), or invent new solutions to unmet requirements (called needs-to-seeds), as determined by the technology readiness assessment described in ISO 16355-5:2017, 10.4.3.2. Invention and innovation methods such as TRIZ (Theory of Inventive Problem Solving) are detailed with guidance and examples in ISO 16355-5:2017, 10.4.3.4 and subsequent clauses. Technology deployment is also used to improve the quality of new concepts in a process called reverse QFD, which is detailed with guidance and examples in ISO 16355-5:2017, 10.4.3.5.1.2. Software and information technology (IT) products get additional guidance and examples of agile development and continuous QFD which are described in ISO 16355-5:2017, 10.4.3.7.1.1 and 10.4.3.7.1.2 respectively. When multiple solutions exist, an evaluation process using AHP, Pugh concept selection, and other methods is detailed in ISO 16355-5:2017, 10.4.3.7.2. These are not included in JIS Q 9025:2003, 6.3. Deployment matrices for subsystems and components are described in ISO/TR 16355-8 9.6.

2.5.4 Cost Deployment

Cost deployment is used to allocate a fixed target cost across the components and processes that make up the product. The target cost is calculated from market considerations that include a competitive selling price, revenue stream based on volume, required profit, and other considerations. This calculation is described in Comprehensive QFD and ISO 16355-5:2017, 10.4.4.2 but is not in JIS Q 9025:2003, 6.4. If there is a mismatch between the target cost and estimated cost based on the design, technology deployment can be used to investigate alternative designs.

Allocating the cost from target to components is performed by function analysis to construct a function tree (ISO 16355-5:2017, (10.4.2.3.3) followed by a series of matrices to transfer customer needs priorities into function weights (ISO 16355-5:2017, 10.4.2.3.4), function weights into subsystem weights (ISO 16355-5:2017, 10.4.4.3), and subsystem weights into component weights (ISO/TR 16355-8:2017, 9.6). When allocating a fixed target such as cost, the typical independent distribution method to calculate weights is replaced by proportional distribution (ISO 16355-5:2017, 10.2.2.4), which better accounts for the number of components that make up product. These ISO clauses give more detailed guidance and examples than JIS Q 9025:2003.

The ISO supplements Comprehensive QFD and the JIS Q 9025:2003 with additional methods, guidance, and examples, for design-to-cost analysis (ISO 16355-5:2017, 10.4.4.5), parametric cost analysis (ISO 16355-5:2017, 10.4.4.6), and value analysis and value engineering (VA/VE) (ISO/TR 16355-8:2017, 9.4).

2.5.5 Reliability Deployment

When designing new products, reliability deployment reminds developers to consider how to mitigate the risk of product failure at the product level, system level, component level, and the process level. Reliability deployment begins with constructing a fault tree (ISO 16355-5:2017, 10.4.3), followed by a series of matrices to transfer customer need priorities into failure mode weights (ISO 16355-5:2017, 10.4.5.5) to check for failure to satisfy the customer, functional requirement weights into failure mode weights (ISO 16355-5:2017, 10.4.5.6) to check for failure to perform, function weights into failure mode weights (ISO 16355-5:2017, 10.4.5.7) to check for failure to function, component weights into failure mode weights (ISO/TR 16355-8:2017, 9.7) to check for component level failures, and process failures (ISO/TR 16355-8:2017, 13.4).

To address how to prevent the causes of failures or mitigate the effects should they occur, failure mode and effects analysis (FMEA) is described in ISO 16355-5:2017, 10.4.5.8) and ISO/TR 16355-8:2017, 9.8 and 10.3.4). FMEA is updated with more precise ratio scale calculations of the risk priority number (RPN) based on AHP. Additional reliability methods and tools are included such as anticipatory failure determination (ISO 16355-5:2017, 10.4.5.8.3) and several others (ISO 16355-5:2017, 10.4.5.8.4).

Reliability deployment is further broadened to address modern concerns such as regulatory, environmental, and sustainability (ISO 16355-5:2017, 10.4.5.9.1), safety (ISO 16355-5:2017, 10.4.5.9.2), and security of information (ISO 16355-5:2017, 10.4.5.9.3). These are explained with guidance and examples not in JIS Q 9025:2003, 6.5.

2.6 QFD-related approaches to optimization (ISO/NP 16355-6)

While still in draft status, part 6 of the ISO 16355 standard will be published as a technical standard (TS) to address design optimization, particularly with regards to different use cases and application environments. It will included methods and tools of robust parameter design based on Taguchi methods and ISO 16335:2014 [24], classical design of experiments (DOE), probabilistic design, response surface methodology (RSM), and other methods that have been used in QFD studies. Optimization is not included in Comprehensive QFD or JIS Q 9025:2003.

2.7 Other approaches to optimization (ISO/NP 16355-7)

While still in draft status, part 7 of the ISO 16355 standard will be published as a technical report (TR) to address other optimization methods and tools that have the potential to be used in QFD studies.

2.8 Guidelines for commercialization and life cycle (ISO/TR 16355-8:2017)

Following design optimization, part 8 of the ISO 16355 standard is a technical report to address component design, build processes, commercialization, support, retirement from use, and input to the next generation product design. It also addresses the work and job function effectiveness and efficiency.

For the most part, Comprehensive QFD and JIS Q 9025:2003 address performance and functional quality of the product to solve a customer problem or enable a customer opportunity in their work or life. There are also non-functional or esteem characteristics of a product that make it attractive or fulfill the user's emotional needs to feel good about oneself or look good to others. Kansei engineering based on the work of Nagamachi [25] is introduced with guidance and examples (ISO/TR 16355-8:2017, 8.1) to help developers understand the impact of aesthetics such as color, shape, and texture in system and component design. This is not in Comprehensive QFD or JIS Q 9025:2003.

Part 8 then deploys to the detailed component and build process matrices and tables in the quality, technology, cost, and reliability analyses of Comprehensive QFD and JIS Q 9025:2003 as shown above, including guidance and examples. The analyses continue with production planning, production, packaging, logistics, customer support, customer satisfaction surveys (ISO 16355-3), end-of-life disposal, and feed-forward of market information for the design of the next generation of products.

Part 8 concludes with improvement in effectiveness and efficiency of the new product development process itself through job function deployment and a systems diagram of a quality assurance network, as partially shown in Comprehensive QFD and JIS Q 9025:2003, 9.6.

3. TRANSITIONING FROM JIS Q 9025:2003 TO ISO 16355

JIS Q 9025:2003 is a very powerful model for implementing Comprehensive QFD; the transition to ISO 16355 should be easy to implement when improvements are useful for the project and team. The implementation sequence in Table 2 is suggested. Generally, the areas to build on JIS Q 9025:2003 are in more precise math, deeper understanding of customers, clarification of business objectives, expanding deployments in both breadth and depth, and integration with other methods and tools.

4. CONCLUSION

Since the first published article in 1966 [26], QFD has grown from the strong roots of Japanese quality management methods and tools into the Japanese standard JIS Q 9025:2003, which is based on the Comprehensive QFD model developed by Akao and others in the 1990s and published in 1998. [10] W. Edwards Deming said that knowledge comes from "outside" the system [27], and as QFD has extended its influence globally over the past thirty years, so has QFD absorbed best practices from worldwide practitioners. Based on papers and case studies presented at national and international QFD Symposia since 1989 [8], the ISO 16355 series of standards brings these Japanese and global methods and tools together to update the new product development process so that it better aligns with today's and tomorrow's customers, suppliers, and competitors.

These global methods and tools not only strengthen the classical Comprehensive QFD model, they also integrate with modern strategic planning, market and consumer research, voice of customer analysis to uncover unspoken needs, and innovation. Then, after product launch, the ISO 16355 provides guidance for ongoing support and environmental sustainability.

Organizations that offer products, services, and information technology to other businesses and consumers in the global economy will face many challenges in the future due to changing political and economic pressures, combined with rapidly advancing technological disruptions. International standards like the ISO 16355 are the compass needle pointing towards a successful future.

Table 2 ISO 16355 implementation phases

	1	2	3	4
Math	Change matrix relationships to 5 or 9 levels and math from ordinal scale to ratio scale. *(ISO 16355-1:2015, 13.1 and ISO 16355-5:2017, 10.2.1)*	Change customer needs prioritization from ordinal scale to ratio scale. *(ISO 16355-1:2015, A13 and ISO 16355-4:2017, 11.2)*	Change quality planning table and design planning table from ordinal scale to ratio scale. *(ISO 16355-4:2017, 12.2 and ISO 16355-5:2017, 10.3.4.5)*	Change FMEA and other calculations from ordinal scale to ratio scale. *(ISO/TR 16355-8:2017, 9.8.2)*
Customers	Visit customers in their gemba to understand their problems and opportunities. *(ISO 16355-2:2017, 9.2.5.2)*	Prioritize which customers to visit first. *(ISO 16355-2:2017, 9.2.3)*	Translate all VOC into *true* customer needs. *(ISO 16355-4:2017, 9.2)*	Uncover unspoken customer needs. *(ISO 16355-2:2017, 9.2.5.2.4 and ISO 16355-4:2017, 10.3)*
Business	Clarify project charter and get team agreement on deliverables. *(ISO 16355-2:2017, 9.1.3)*	Clarity project scope boundaries. *(ISO 16355-2:2017, 9.1.5)*	Prioritize projects and project goals. *(ISO 16355-2:2017, 9.1.2.8 and 9.1.3.3)*	Clarify relationship between project goals and organization strategy. *(ISO 16355-2:2017, 9.1.2)*
Deployments	Implement Blitz QFD® to precede house of quality table. *(ISO 16355-12:2015, A.2)*	Implement maximum value table to precede house of quality table. *(ISO 16355-5:2017, 9.2)*	Expand beyond house of quality to other quality deployment matrices and tables. *(ISO 16355-5:2017, 10.4.2 and ISO/TR 16355-8:2017, 9)*	Expand beyond quality deployment to technology, cost, reliability, and other deployments. *(ISO 16355-5:2017, 10.4.3, 10.4.4, 10.4.5 and ISO/TR 16355-8:2017, 9)*
Tools	Analytic hierarchy process (AHP) *(ISO16355-1:2015, 13.1 and A.13; ISO 16355-2:2017, 9.1.2.8 and 9.1.3.3; ISO16355-4:2017, 11and 12.2; ISO 16355-5:2017, 10.2 and 10.3.4.5 and 10.4.3.7.2.5; ISO/TR 16355-8:2017, 9.8.2)*	TRIZ *(ISO 16355-5:2017, 10.4.3.4),* Pugh concept selection *(ISO 16355-5:2017, 10.4.3.7.2),* Value analysis/engineering (VA/VE) *(ISO/TR 16355-8:2017, 9.4)*	Quantitative VOC analysis. *(ISO 16355-3)*	Hoshin kanri *(ISO 16355-2:2017, 9.1.2.2),* New Lanchester strategy *(ISO 16355-2:2017, 9.1.2.6),* Kansei engineering *(ISO/TR 16355-8:2017, 8.1)*

Annex 1 JIS Q 9025 - ISO 16355 Cross Reference [6]

JIS Q 9025		ISO 16355	Clause	
0	Introduction	ISO 16355-1	0	Introduction
0.1	General	ISO 16355-1	0	Introduction
0.2	Consistency with other standards	ISO 16355-1	Bibliography	[127] - [131]
0.3	Relationship with JIS Q 9000 family			
0.4	Compatibility with other management systems	ISO 16355-1	5	Integration of QFD and product development methods
1	Scope	ISO 16355-1	1	Scope
2	Normative reference	ISO 16355-1	2	Normative references
3	Terms and definitions	ISO 16355-1	3	Terms and definitions
3.1	Terms related to quality function deployment	ISO 16355-1	3	Terms and definitions
3.1.1	transformation	ISO 16355-1	4.1 f)	improve internal communications through transformation
3.1.2	deployment	ISO 16355-1	12.1	Translation of one information set into another, General
3.1.3	deployment table	ISO 16355-1	9	Structuring information sets
3.1.4	matrix	ISO 16355-1	13.1	Transfer of prioritization
3.1.5	correlation strength	ISO 16355-1	13.1	Transfer of prioritization
3.1.6	quality function deployment (QFD)	ISO 16355-1	3.1	quality function deployment (QFD)
3.1.7	quality deployment	ISO 16355-1	13.5.2	Quality deployment
3.1.8	engineering deployment	ISO 16355-1	13.5.4	Technology deployment
3.1.9	cost deployment	ISO 16355-1	13.5.6	Cost deployment
3.1.10	reliability deployment	ISO 16355-1	13.5.8	Reliability deployment
3.1.11	job function deployment	ISO 16355-1	4.2	QFD use of the word function
3.1.12	voice of the customer	ISO 16355-1	3.2	voice of the customer
3.1.13	required quality	ISO 16355-1	3.3	customer need
3.1.13	required quality	ISO 16355-4	9.1.3.3	Customer needs
3.1.14	bottleneck engineering (BNE)	ISO 16355-5	10.4.3.8.2	Resolving engineering bottlenecks
3.1.15	quality assurance (QA) table	ISO 16355-8	9.9	Quality assurance table
3.2	Terms related to quality	ISO 16355-1	3	Terms and definitions
3.2.1	required quality deployment table	ISO 16355-4	10.3.1	Hierarchy diagram, General

JIS Q 9025		ISO 16355	Clause	
3.2.2	quality characteristic deployment table	ISO 16355-5	9.3.6.2.2	Functional requirements hierarchy
3.2.3	quality table	ISO 16355-5	9.3.6.2.3	Matrix
3.2.4	quality of planning	ISO 16355-4	12.2	quality planning table
3.2.5	quality of design	ISO 16355-5	9.3.6.2.3	Matrix
3.2.6	ratio of level improvement	ISO 16355-4	12.2 3)	competition section
3.2.7	selling point	ISO 16355-4	12.2 4)	selling point
3.2.8	unadjusted weight	ISO 16355-4	12.2 6)	unadjusted customer need priority
3.2.9	adjusted weight of required quality	ISO 16355-4	12.2 6)	adjusted customer need priority
3.2.10	quality characteristic weight	ISO 16355-5	10.3.4.5	Weighted design planning table
4	Basic concepts	ISO 16355-1	4	Basic concepts of QFD
4.1	General	ISO 16355-1	4.1	Theory and principles of QFD
4.2	Quality function deployment in quality management	ISO 16355-1	5.1	QFD support for product development methods
4.2 a)	Customer focus	ISO 16355-1	4.1 c)	Listen to the voice of the customer
4.2 b)	Participation of people	ISO 16355-1	7	QFD team membership
4.2 c)	Early detection of technological issues	ISO 16355-5	10.4.3.1	Technology deployment, General
4.2 d)	Development management	ISO 16355-1	6	Types of QFD projects
4.2 e)	Secure quality assurance	ISO 16355-1	5.2	Organization of the QFD flow
4.2 f)	Multilateral evaluation	ISO 16355-1	13.5	Transferring deployment sets by dimensions
4.3	Principles of quality function deployment	ISO 16355-1	4.1	Theory and principles of QFD
4.3 a)	Principle of deployment	ISO 16355-1	13.6	Transferring deployment sets by levels
4.3 b)	Principle of segmentation and integration	ISO 16355-4	9.2.3	Cause-to-effect diagram
4.3 c)	Principle of multi-dimensional development and visualization	ISO 16355-1	12	Translation of one information set into another
4.3 d)	Principle of consolidation and breakdown	ISO 16355-1	9	Structuring information sets
4.3 e)	Principle of transformation	ISO 16355-1	12	Translation of one information set into another

JIS Q 9025		**ISO 16355**	**Clause**	
5.1	Quality table, General	ISO 16355-5	9.3.6	House of quality
5.2	Deployment table and matrix	ISO 16355-5	9.3	L-Matrices
5.2.1	Deployment table	ISO 16355-4	10.3	Hierarchy diagram
5.2.2	Matrix	ISO 16355-5	9.3	L-Matrices
5.2.3	Transformation in level of importance	ISO 16355-5	10.2	Transfer of prioritization
5.2.3 a)	Independent rating method	ISO 16355-5	10.2.4.2	Independent distribution
5.2.3 b)	Proportional distribution method	ISO 16355-5	10.2.4.4	Proportional distribution
5.3	Composition of the quality table	ISO 16355-5	9.3.6.2	Information in the house of quality
5.3 a)	Required quality deployment table	ISO 16355-5	9.3.6.2 a)	Customer needs hierarchy
5.3 b)	Quality characteristic deployment table	ISO 16355-5	9.3.6.2 b)	Functional requirements hierarchy
5.3 c)	Matrix	ISO 16355-5	9.3.6.2 c)	Matrix
5.3 d)	Quality planning table	ISO 16355-5	9.3.6.2 d)	Quality planning table
5.3 d)	Quality planning table	ISO 16355-5	10.3.2	Quantify row information
5.3 e)	Design quality table	ISO 16355-5	9.3.6.2 e)	Design planning table
5.3 f)	Quality characteristic correlation table	ISO 16355-5	9.3.6.2 f)	Functional requirements correlation matrix
5.4	Quality table creation procedure	ISO 16355-5	9.3.6	House of quality
5.4.1	Required quality and quality of planning	ISO 16355-4	12.2	Quality planning table (QPT)
5.4.1 a)	Gathering "voice of the customer"	ISO 16355-2	9.2.5	Sources of VOC or VOS
5.4.1 b)	Transformation into required quality	ISO 16355-4	9.2	Translating VOC and VOS into customer needs
5.4.1 c)	Creation of required quality deployment table	ISO 16355-4	10	Structuring information sets
5.4.1 d)	Calculation of order of importance in required quality	ISO 16355-4	11	Prioritization
5.4.1 e)	Comparative analysis	ISO 16355-4	12.2 3)	QPT competition section
5.4.1 f)	Establishment of quality of planning	ISO 16355-4	12.2 3)	QPT competition section
5.4.1 g)	Calculation of the rate of improvement	ISO 16355-4	12.2 3)	QPT competition section
5.4.1 h)	Establishment of selling point	ISO 16355-4	12.2 4)	QPT selling point
5.4.1 i)	Calculation of unadjusted weight and adjusted weight of required quality	ISO 16355-4	12.2 6)	QPT global weights

JIS Q 9025		**ISO 16355**	**Clause**	
5.4.2	Quality table and design quality	ISO 16355-5	10.3.4.1	Design planning table information for the house of quality
5.4.2 a)	Identify quality characteristics	ISO 16355-5	9.3.6.2.2	columns of the house of quality
5.4.2 b)	Create quality characteristic deployment table	ISO 16355-5	9.3.6.2.2	functional requirements hierarchy
5.4.2 c)	Create matrix for required quality deployment table and quality characteristic deployment table	ISO 16355-5	9.3.6.2.3	matrix
5.4.2 d)	Enter correlations	ISO 16355-5	10.2.1	Quantify strength of relationships in the matrix
5.4.2 e)	Transform weight	ISO 16355-5	10.2.3	Calculate the column weights
5.4.2 f)	Conduct comparative analysis	ISO 16355-5	10.3.4.3	Unweighted design planning table
5.4.2 g)	Establish quality of design	ISO 16355-5	10.3.4.3	Unweighted design planning table
6	Quality function deployment	ISO 16355-5	10.4	Transferring deployment sets by dimensions and levels
6.1	Quality function deployment, General	ISO 16355-5	10.4.1	Deployment sets
6.2	Quality deployment	ISO 16355-5	10.4.2	Quality deployment
6.2.1	Quality deployment, Objective	ISO 16355-5	10.4.2.1.1	Quality deployment, Objective
6.2.2	Quality deployment, Composition	ISO 16355-5	10.4.2.1.2	Quality deployment, Composition
6.3	Engineering deployment	ISO 16355-5	10.4.3	Technology deployment
6.3.1	Engineering deployment, Objective	ISO 16355-5	10.4.3.1.1	Technology deployment, Objective
6.3.2	Engineering deployment, Composition	ISO 16355-5	10.4.3.1.2	Technology deployment, Composition
6.4	Cost deployment	ISO 16355-5	10.4.4	Cost deployment
6.4.1	Cost deployment, Objective	ISO 16355-5	10.4.4.1.1	Cost deployment, Objective
6.4.2	Cost deployment, Composition	ISO 16355-5	10.4.4.1.2	Cost deployment, Composition
6.5	Reliability deployment	ISO 16355-5	10.4.5	Reliability deployment
6.5.1	Reliability deployment, Objective	ISO 16355-5	10.4.5.1.1	Reliability deployment, Objective

JIS Q 9025		ISO 16355	Clause	
6.5.2	Reliability deployment, Composition	ISO 16355-5	10.4.5.1.2	Reliability deployment, Composition
6.6	Job function deployment table	ISO 16355-8	20	Quality assurance network diagram
6.6.1	Job function deployment table, Objective	ISO 16355-8	20.1	Quality assurance network diagram, Objective
6.6.2	Job function deployment table, Composition	ISO 16355-8	20,2	Quality assurance network diagram, Composition
7	Application guide	ISO 16355-1	6.1	Types of QFD projects, General
7.1	Application guide, Objective	ISO 16355-1	4.1	Theory and principles of QFD
7.2	Frame corresponding to objective	ISO 16355-1	6.1	Types of QFD projects, General
7.2 a)	Existing product assembly	ISO 16355-5	10.4.1.2 a)	improve performance of new or existing product
7.2 b)	Service	ISO 16355-8	12.1.5	Project work or task management
7.2 c)	Software	ISO 16355-5	10.4.3.7.1.1	Agile development
7.2 d)	Production goods	ISO 16355-8	13.5.1	QC process table based work standard
7.2 e)	Concept planning	ISO 16355-5	10.4.3.6	Develop system, subsystem concepts
7.2 f)	Parts	ISO 16355-8	9.3	Functional requirements - components matrix
7.2 g)	Environment-compliant design	ISO 16355-5	10.4.1.2 e)	regulatory deployment
7.3	Use in design review	ISO 16355-8	11	Testing, validation, design review, and prototyping
7.3 a)	Quality function deployment in design review in the planning stage	ISO 16355-8	11.4 a)	Planning stage design review
7.3 b)	Quality function deployment in design review in the prototype drawing production stage	ISO 16355-8	11.4 b)	Prototype drawing and pre-production stage design review
7.3 c)	Quality function deployment in design review at completion of mass-production prototype	ISO 16355-8	11.4 c)	Production stage design review
8	Introduction and application to organizations	ISO 16355-1	8	QFD voices

JIS Q 9025		**ISO 16355**	**Clause**	
8.1	Introduction of quality function deployment	ISO 16355-1	8.1	Voice of business
8.2	Formation of the team	ISO 16355-1	7	QFD team membership
8.3	Quality function deployment using information technology	ISO 16355-1	6.1 f)	document and preserve market and technical knowledge
8.4	Information configuration	ISO 16355-4	9.1.3	Information contained in VOC and VOS
8.4 a)	Voice of the consumer	ISO 16355-4	9.1.3.3	Customer needs
8.4 b)	Engineering characteristics	ISO 16355-4	9.1.3.4	Functional requirements
8.4 c)	Product function	ISO 16355-4	9.1.3.5	Function
8.4 d)	Materials used	ISO 16355-4	9.1.3.9	Material
8.4 e)	Parts and components	ISO 16355-4	9.1.3.8	Subsystem or component
8.4 f)	Mechanisms	ISO 16355-4	9.1.3.8	Subsystem or component
8.4 g)	Seeds	ISO 16355-5	10.4.3.3	Needs to seeds technology development
8.4 h)	Technology	ISO 16355-4	9.1.3.6	Technology
8.4 i)	Bottleneck engineering	ISO 16355-5	10.4.3.8.2	Resolving engineering bottlenecks
8.4 j)	Cost	ISO 16355-4	9.1.3.2	Cost
8.4k)	Failure mode	ISO 16355-4	9.1.3.7	Reliability or failure mode
8.4 l)	Manufacturing methods	ISO 16355-4	9.1.3.13	Manufacturing or build methods
8.4 m)	Measurement method	ISO 16355-4	9.1.3.14	Measurement methods
8.4 n)	Job functions	ISO 16355-4	9.1.3.11	Process
8.4 o)	Assurance items	ISO 16355-4	9.1.3.15	Quality
9	Related methods	ISO 16355-1	5	Integration of QFD and product development methods
9.1	Related methods, General	ISO 16355-1	5.1	QFD support for product development methods
9.2	Relevant methods in quality deployment	ISO 16355-1	13.5.3	Quality deployment, Applicable tools and methods
9.2 a)	Questionnaire survey	ISO 16355-1	8.2.9	Sources of VOC and VOS
9.2 b)	Test planning method	ISO 16355-1	16	Prototyping, testing, and validation
9.2 c)	Quality engineering	ISO 16355-1	15	Design optimization
9.2 d)	Product planning method	ISO 16355-1	Reference 35	7 Product planning tools

JIS Q 9025		**ISO 16355**	**Clause**	
9.2 e)	Multivariate analysis	ISO 16355-8	10	Statistical analysis of customers' evaluations of products
9.3	Relevant methods in engineering deployment	ISO 16355-1	13.5.5	Technology deployment, Applicable tools and methods
9.3 a)	Comparison or proposals	ISO 16355-1	13.5.5 f)	Super Pugh concept selection with AHP
9.3 b)	Reviewed dendrogram	ISO 16355-1	13.5.5 e)	Reviewed dendrogram
9.4	Relevant methods in cost deployment	ISO 16355-1	13.5.7	Technology deployment, Applicable tools and methods
9.4 a)	Cost planning	ISO 16355-5	10.4.4.5	Design-to-cost analysis
9.4 b)	Balanced scorecard	ISO 16355-2	9.1.2.7.2	Balanced scorecard
9.5	Relevant methods in reliability deployment	ISO 16355-1	13.5.9	Reliability deployment, Applicable tools and methods
9.5 a)	FTA	ISO 16355-1	13.5.9.a)	Fault tree analysis
9.5 b)	FMEA	ISO 16355-1	13.5.9.b)	Failure mode and effects analysis
9.5 c)	Design review	ISO 16355-1	16.2 g)	Prototyping, testing, and validation, Applicable tools and methods
9.6	Relevant methods in job function deployment	ISO 16355-8	20.2	Quality assurance network, Composition
9.6 a)	Value analysis (VA) and value engineering (VE)	ISO 16355-5	10.4.2.3.2 a)	Value analysis (VA) and value engineering (VE)
9.6 b)	Quality assurance system diagram	ISO 16355-8	20	Quality assurance network
9.6 c)	Quality assurance activity chart	ISO 16355-8	20.2	Quality assurance network, Composition
Annex 1 1	Subsystem and process deployment based on quality deployment	ISO 16355-8	13	Build and process planning
Annex 1 1 a)	Create quality table	ISO 16355-5	9.3.6	House of quality
Annex 1 1 b)	Create subsystem deployment table	ISO 16355-5	10.4.3.6.3	Structuring concepts
Annex 1 1 c)	Create unit/parts deployment table	ISO 16355-5	10.4.3.6.3	Structuring concepts
Annex 1 1 d)	Create parts deployment table	ISO 16355-8	9.3.2	components hierarchy diagram

JIS Q 9025		**ISO 16355**	**Clause**	
Annex 1 1 e)	Create quality characteristics - subsystem matrix	ISO 16355-5	10.4.3.7.2.4	Selecting concepts using QFD criteria
Annex 1 1 f)	Create subsystem - unit/parts matrix	ISO 16355-8	9.6.2	Building the subsystem - components matrix
Annex 1 1 g)	Create unit/parts - parts matrix	ISO 16355-8	9.6.2	Building the subsystem - components matrix
Annex 1 1 h)	Create process deployment table	ISO 16355-8	13.5.2.2 2)	process steps
Annex 1 1 i)	Create quality characteristics - process matrix	ISO 16355-8	13.5.2.2	Building the functional requirements - process matrix
Annex 1 1 j)	Create process element deployment table	ISO 16355-8	13.3	Quality control table for component production and assembly
Annex 1 1 k)	Create process - process element matrix	ISO 16355-8	13.2	Quality control process planning table
Annex 1 1 l)	Create QA chart	ISO 16355-8	9.9.2	Building the QA table
Annex 1 1 l)	Create QC process chart	ISO 16355-8	13.5.1	QC process table based work standard
Annex 1 2	Cost deployment	ISO 16355-5	10.4.4	Cost deployment
Annex 1 2 a)	Establish target cost	ISO 16355-5	10.4.4.2	Target cost estimation
Annex 1 2 b)	Create function deployment table	ISO 16355-5	10.4.2.3.3	Building the function tree
Annex 1 2 c)	Create quality characteristics deployment table	ISO 16355-5	9.3.6.2.2	functional requirements hierarchy
Annex 1 2 d)	Create mechanism deployment table	ISO 16355-5	10.4.3.6.3	Structuring concepts
Annex 1 2 e)	Create parts deployment table	ISO 16355-8	9.3.2 2)	components hierarchy diagram
Annex 1 2 f)	Create quality characteristics - function matrix	ISO 16355-5	10.4.2.4.3	Functional requirements - function matrix
Annex 1 2 g)	Create function - mechanism matrix	ISO 16355-5	10.4.4.3.3	Building the function - system/subsystem matrix
Annex 1 2 h)	Create function - parts matrix	ISO 16355-8	9.5.2	Building the function-component matrix
Annex 1 2 i)	Transform QC weight - function weight	ISO 16355-5	10.4.2.4.3 4)	Transfer priorities of functional requirements to functions
Annex 1 2 i)	Transform mechanism weight - part weight	ISO 16355-8	9.6.2 4)	Transfer priorities of subsystems to components

JIS Q 9025		ISO 16355	Clause	
Annex 1 2 j)	Allocate target cost to each weight	ISO 16355-8	9.6.2 5)	Allocate target cost of subsystems to components
Annex 1 2 k)	Identify cost bottlenecks	ISO 16355-8	9.6.2 6)	Identify components that are problematic to quality and cost
Annex 1 3	Engineering deployment	ISO 16355-5	10.4.3	Technology deployment
Annex 1 3 a)	Identify criteria for bottlenecks	ISO 16355-5	10.4.3.2	Assessing technology readiness
Annex 1 3 b)	Identify parts and technology bottlenecks	ISO 16355-5	10.4.3.4.1	Revealing technical contradictions
Annex 1 3 c)	Review bottleneck alternative solutions	ISO 16355-5	10.4.3.7.2	Selecting concepts using Pugh and super Pugh methods
Annex 1 3	Reliability deployment	ISO 16355-5	10.4.5	Reliability deployment
Annex 1 3 a)	Create required quality deployment table	ISO 16355-4	10.3.2	Steps to make hierarchy diagram
Annex 1 3 b)	Create quality characteristics deployment table	ISO 16355-5	9.3.6.2.2	functional requirements hierarchy
Annex 1 3 c)	Create required quality - quality characteristics matrix	ISO 16355-5	9.3.6	House of quality
Annex 1 3 d)	Identify assurance items from key required quality	ISO 16355-5	10.4.5.5	Customer needs - failure mode matrix
Annex 1 3 d)	Identify assurance items from key quality characteristics	ISO 16355-5	10.4.5.6	Functional requirements - failure mode matrix
Annex 1 3 e)	Conduct FTA on assurance items	ISO 16355-5	10.4.5.4	Fault tree analysis
Annex 1 3 f)	Show FTA diagram	ISO 16355-5	Figure 13	Building the fault tree
Annex 1 3 g)	Create FT - unit deployment matrix	ISO 16355-8	9.7.2	Building the component - failure mode matrix
Annex 1 3 h)	Create FT - part matrix	ISO 16355-8	9.7.2	Building the component - failure mode matrix
Annex 1 3 i)	FMEA of components and reliability bottlenecks	ISO 16355-8	9.8	Component failure mode and effects analysis (FMEA)
Annex 1 5	Quality function deployment as management system	ISO 16355-8	20	Quality assurance network
Annex 1 5 a)	Identify job functions for assuring quality	ISO 16355-8	20.2	Quality assurance network, Composition
Annex 1 5 b)	Create job function deployment table	ISO 16355-8	20.2	Quality assurance network, Composition
Annex 1 5 c)	Identify product quality assurance items	ISO 16355-8	20.2	Quality assurance network, Composition

JIS Q 9025		**ISO 16355**	**Clause**	
Annex 1 5 d)	Create job function - quality assurance items matrix	ISO 16355-8	20.1	Quality assurance network, objective, note
Annex 1 5 e)	Create list of quality assurance items and quality assurance system diagram	ISO 16355-8	Figure 8	Quality assurance network diagram
Annex 2 Table 1	Example of required quality deployment table	ISO 16355-4	Table 4	Customer needs hierarchy diagram
Annex 3 Table 1	Example of quality characteristic deployment table	ISO 16355-5	Figure 6	Hierarchy diagram of functional requirements
Annex 4 Table 1	Example of quality table	ISO 16355-5	Table 3	Customer needs - functional requirements matrix (house of quality)
Annex 5 Table 1	Example of quality of planning chart	ISO 16355-4	Table 12	Weighted quality planning table
Annex 6 Table 1	Example of transforming order of importance	ISO 16355-5	Table 5	Customer needs - functional requirements matrix (house of quality), weighted
Annex 7 Table 1	Example of QA chart	ISO 16355-8	Table 20	QA table
Annex 8 Table 1	Example of QC process chart	ISO 16355-8	Table 30	QC process table

BIOGRAPHY OF THE AUTHOR

Glenn H. Mazur has been active in QFD since its inception in North America, and has worked extensively with the founders of QFD on their teaching and consulting visits from Japan. He is a leader in the application of QFD as well as conducting advanced QFD research, and is the Conference Chair for the North American Symposium on Quality Function Deployment. Glenn is the Executive Director of the QFD Institute and International Council for QFD, retired Adjunct Lecturer on TQM at the University of Michigan College of Engineering, and is a senior member of the American Society for Quality (ASQ), and the Japanese Society for Quality Control (JSQC). He is a certified QFD Red Belt® (highest level), one of two in North America. He is a certified QFD-Architekt #A21907 by QFD Institut Deutschland. He is honorary president of the Hong Kong QFD Association and Asia QFD Association. He is convenor of the ISO Working Group which has written the ISO 16355 for QFD, US expert to TC176 revising the ISO/TR 10017 technical report on guidance on statistical techniques for ISO 9001, and US expert to TC 279 writing ISO 50501 on establishment of a framework for tools and methods related to innovation management and ISO 50503 on criteria for selecting tools and methods. He is an Academician and Secretary-Treasurer of the International Academy for Quality.

REFERENCES

[1] "ISO/TC 69 (Applications of statistical methods) Paris Plenary Report," *Standardization and Quality Control,* vol. 63, no. 10, pp. 32-33, October 2010.

[2] G. H. Mazur, "Using Quality Function Deployment to Write an ISO Standard for QFD," *Quality Engineering,* vol. 24, no. 3, pp. 436-443, 2012.

[3] ISO 16355-1:2015, "Applications of statistical and related methods to new technology and product development process - Part 1: General principles and perspectives of Quality Function Deployment (QFD)," International Standards Organization, Geneva, Switzerland, 2015.

[4] ISO 16355-2:2017, "Applications of statistical and related methods to new technology and product development process - Part 2: Acquisition of Non-quantitative Voice of Customer and Voice of Stakeholder," International Standards Organization, Geneva, Switzerland, 2017.

[5] ISO 16355-4:2017, "Applications of statistical and related methods to new technology and product development process - Part 4: Analysis of Non-Quantitative and Quantitative VOC/VOS," International Standards Organization, Geneva Switzerland, 2017.

[6] ISO 16355-5:2017, "Applications of statistical and related methods to new technology and product development process - Part 5: Solution Strategy," International Standards Organization, Geneva Switzerland, 2017.

[7] ISO/TR 16355-8:2017, "Applications of statistical and related methods to new technology and product development process - Part 8 Commercialization.," International Standards Organization, Geneva, Switzerland, 2017.

[8] QFD Institute, ISO 16355-1:2015 Bibliography Papers, G. Mazur, Ed., Ann Arbor: QFD Institute, 2015, p. 1400.

[9] Y. Akao, Quality Function Deployment: Integrating Customer Requirements into Product Design, Portland: Productivity Press, 1990.

[10] 赤尾洋二編, 新製品開発のための品質展開活用の実際, 日本規格協会, 1988.

[11] J. R. Hauser and D. Clausing, "The House of Quality," *Harvard Business Review,* no. May-June, 1988.

[12] R. E. Zultner, "Project QFD: Managing Software Development Better with Blitz QFD," in *Transactions of the 9th Symposium on QFD,* Ann Arbor MI, 1997.

[13] G. Herzwurm and S. Schockert, "What are the Best Practices of QFD?," in *Proceedings of the 12th International Symposium on QFD,* Tokyo, 2006.

[14] Japanese Industrial Standard, "JIS Q 9025:2003(E) Performance improvement of management systems - Guidelines for quality function deployment," Japanese Standards Association, Tokyo, 2003.

[15] T. L. Saaty, "The Analytic Hierarchy Process: How to Measure Intangibles in a Meaningful Way Side by Side," Ann Arbor, 2007.

[16] 刀根 薫, ゲーム感覚意思決定法－ＡＨＰ入門, Tokyo: 日科技連出版社, 1986.

[17] K. Nishimura, "Ship Design and Quality Chart," *Quality Control,* vol. 23, pp. 71-74, 1972.

[18] 山本 直樹, "三菱重工､豪華客船で払った高すぎる授業料," 16 4 2016. [Online]. Available: http://toyokeizai.net/articles/-/113297.

[19] G. H. Mazur, H. Takasu and M. Ono, Policy Management: Quality Approach to Strategic Planning, Torrance: Integrated Quality Dynamics, Inc., 1998.

[20] Japanese Industrial Standard, "JIS Q 9023:2003(E) Performance improvement of management systems - Guidelines for managemant by policy," Japanese Standards Association, Tokyo, 2003.

[21] Japanese Society for Quality Control, "JSQC-Std 33-001:2016 方針管理の指針 (Guidelines for Policy Management)," Japanese Society for Quality Control, Tokyo, 2016.

[22] 大藤 正, 小野道照 and 赤尾洋二, 品質展開法（１）－品質表の作成と演習－, vol. 1, Tokyo: 日科技連出版社, 1990.

[23] N. Kano, N. Seraku, F. Takahashi and S. Tsuji, "Attractive Quality and Must-be Quality," *Hinshitsu,* vol. 14, no. 2, 1984.

[24] ISO 16336:2014, "Applications of statistical and related methods to new technology and product development process — Robust parameter design (RPD)," International Standards Organization, Geneva Switzerland, 2014.

[25] M. Nagamachi and A. M. Lokman, Innovations of Kansei Engineering, CRC Press, 2010.

[26] K. Oshiumi, "Perfecting Quality Assurance System in Plants," *Quality Control,* pp. 62-67, May (supp.) 1966.

[27] W. E. Deming, The New Economics, Cambridge, MA: MIT-Center for Advanced Educational Services, 1994, p. 92.