Beyond ISO 16355: QFD for a Digital World

Glenn H. Mazur, QFD Red Belt®

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

ABSTRACT

The ISO 16355 standard is now published. It is a "framework" based on Dr. Akao's Comprehensive QFD model and includes guidance in its application to manufacturing, service, and IT products. Products in the future and the processes for making them will become smart systems of hardware, human-ware, and software. To address this complexity, QFD is now being integrated with methods like Systems Engineering, Manufacturing 4.0, Internet of Things, Big Data, Internet Security, Design Thinking, and other approaches. This keynote presentation will discuss current and ongoing research in Systems Engineering, and how the international QFD community is adapting and growing in this digital age.

KEYWORDS

QFD, ISO 16355, Systems Engineering

1. INTRODUCTION

The new ISO 16355 standard for QFD is published and represents global best practice in new product development. 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) [1]

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

— 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) [3]

— Part 5: Solution Strategy (ISO 16355-5:2017) [4]

— 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). [5]

With this best practice baseline in place, this paper proposes ideas for QFD experts to reflect on what comes next. First comes a revision of the just-published standards, based on feedback from users. This will include other methods and tools to connect such as Big Data and Systems Engineering, strengthening connections and examples of methods and tools that are already included such as agile development and security, and expansion to applications in other fields such as societal and non-governmental organizations (NGO).

2. ISO/AWI 16355-1, -2, -4, -5, AND -8 REVISIONS

In June 2017, the author and Convenor of the ISO 16355 working group (TC69/SC8/WG2) proposed that revisions of the new standard begin as soon as possible based on feedback from users and emerging research in QFD. These revisions will be made currently with the ongoing drafts of parts 3, 6, and 7.

3. INTEGRATION OF ISO 16355 WITH SYSTEMS ENGINEERING

The increasing complexity of digital products with integrated software, mechanical, and services requires that developers think in terms of interfacing systems, subsystems, and modules that combine software, hardware, and human-ware in various configurations to perform functions necessary to satisfy customer needs. The rapid pace of technology advancements and the demands of faster time-to-market requires multiple engineering disciplines to design a product and marketing to define customer needs. This has been especially true in transportation, defense, and information technology sectors where there are many customers and stakeholders that must be satisfied.

Systems Engineering (SE) is based on the principle of defining "what" a product must do (called the problem space) before defining "how" it will do it (called the solution space) throughout the product's life cycle. What is often difficult in SE is defining "why" the product must do something, i.e. customer needs. QFD shares some principles as SE but also includes a strong front-end tool set to define and prioritize multiple customer/stakeholders and their needs.

3.1 Compatibility of SE and QFD

This compatibility was recognized as early as 1989, with the need to define the value chain of customers of an automotive wire harness as including vehicle assembly plant installers, service repair mechanics at dealerships, if not the actual car buyer or driver. [6] Vehicle wire harnesses act as an interface of all the electrical components, including sensors and actuators, and as mechanically operated devices are being replaced by digitally operated ones, the requirements of the wire harness have become very complex, making both installation and repair difficult. Based on the QFD analysis, customer needs of the installers and repair mechanics were better understood and prioritized. This enabled the team (which included a customer) to evaluate potential solution alternatives to propose to management for consideration. Key among these needs were "eliminate hazardous routing" of the harness, which could then be deployed to how the harness was manufactured and how it was installed in the assembly plant by the customer. A 1993 study of SE and QFD in the defense industry identified how QFD was useful in discussing non-negotiable needs with multiple levels within the customer's organization, based on asking not just "what" was required but "why." [7] The study also discovered that typical SE requirements such as cost and risk could be handled in QFD not as needs but as filters when evaluating solutions. The QFD analyses included a matrix to transfer customer need priorities to design parameters (problem space) and a matrix to transfer design parameters to selected features (solution space).

3.2 SE and QFD for Lower Cost and Shorter Schedules

In 1998, an aerospace industry paper identified the need for an organization to take a systems engineering approach in order to realize product opportunities in an environment demanding lower cost and shorter schedules. It was recognized that this could be achieved with better requirements management at the front-end of the SE process, and QFD was identified as a key process to define and prioritize customer expectations and provide requirements traceability. [8] The QFD matrices further provided a mechanism to update both customer needs priorities and the relationships with technical parameters as the project progressed and more was learned. A 1999 study on SE, QFD, and concurrent engineering for building architecture discussed the need for more collaborative interactions between customers and engineers early in the requirements formulation phase, as well as during development. [9]

3.3 SE V-Model and QFD

The use of the SE V-model (Figure 1) and QFD in information technology (IT) was presented in 2008 as a way to clarify system boundaries and interfaces with the client-side staff in a large governmental project. [10] In many projects, customers suggest their preferred solutions which may be insufficient, incomplete, or out-of-date. The use of QFD early on resulted in a solution that met all requirements and at less cost. The QFD matrices also provided a traceable means to decompose stakeholder requirements into functional architectural components and then these into physical architectural components which would reflect customer priorities during all phases of development and roll-out. The authors identified specific QFD steps to use, namely:

a. identify processes key to the system & system components using Supplier Input, Process, Output, Customer (SIPOC) analysis;

b. confirm all stakeholders for those processes;

c. confirm system and component boundaries using the preceding information;

d. clarify stakeholder requirements for the system and major components;

e. prioritize these requirements;

f. identify underlying conflicts in the requirements to identify technical and program risks;

g. use the QFD to translate these into the voice of the engineer and prioritize the engineering requirements. [10]

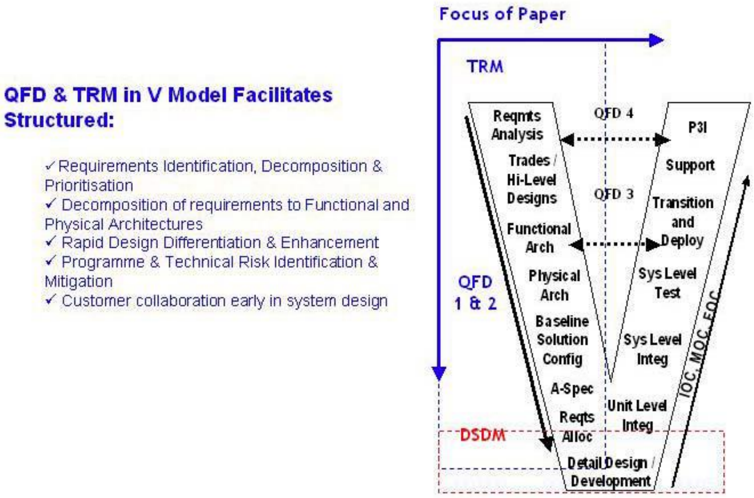

Figure 1 Systems engineering V model [10]

Step d. above led to voice of customer workshops attended by representatives of both customer and supplier side stakeholders. Using QFD methods and tools, the following benefits were observed:

- users developed a holistic understanding of their needs and those of other stakeholders and appreciated the ‘systems context’ for their area;
- an understanding of conflicting requirements was established with the customer early;
- many stakeholders reported they felt enfranchised through attendance at the workshops – they were being listened to – gripes and all;
- the design team got to the heart of the key stakeholder drivers – and understood areas still requiring clarification by the client;
- the design team better understood scope and constraints of the system;
- critical relationships were established between customer groups and the supply team they established a communication framework for use by all parties. [10]

3.4 Product Lifecycle Management

A 2010 paper on QFD, SE, and product lifecycle management confirms the role of QFD as a "suitable tool for the activities to define the detailed specification of the product or part" and to assure its quality. [11] This paper addresses the use of virtual reality and other software solutions in the design and development of automotive parts by first defining the functions necessary to fulfill customer requirements.

3.5 QFD for IT Systems

The difficulty in defining customer requirements in complex defense-related information technology (IT) systems was further explored in 2011 to reduce the time and cost of project planning and process tailoring associated with the increasing demands for "more capability, increased awareness, higher performance, faster response and greater technological advantage." The authors propose the "complementary application of SE and QFD to improve stakeholder communication, facilitate subsystem design effort and identify functional priorities and capability gaps of complex systems of systems." [12] This would facilitate understanding the real customer problem or opportunity, the true operational environment, and hidden needs that are difficult for the customer to articulate at the early stages of the project when the behavior of the systems were not yet well understood. The authors assign roles to both SE and QFD: "SE can be generally characterized as a function-based analysis approach to embed quality requirements into system design, and QFD can be generally characterized as a product-based analysis approach to embed quality functions into organizational product development processes…. this apparent difference in engineering perspective may enable complementary application through the use of QFD-based matrices as top-level representations of the complex system functional architecture and related non-functional performance requirements and design attributes." [12] The importance of separating functional requirements and non-functional performance requirements into separate matrices, especially in Comprehensive QFD's subsystem analysis, was recommended to further align the SE and QFD approaches. Further, the use of QFD helped the verification and validation steps in the SE process, which served as "test points to measure compliance with customer and technical requirements and identify deficiencies in design."

3.6 SE and ISO 16355 Integration

The ISO 16355-2:2017 standard for QFD [2] has better clarified its role at the front end of SE in terms of better understanding the strategic mission objectives, scope, and constraints of new product projects. The broader strategic goals may be defined using a number of tools explained in the standard, and these strategic goals may be clarified into business and project goals. As in the example of one case study on large, complex governmental projects, the strategic goals may represent external missions and societal goals, such as reduction in carbon dioxide that contributes to global warming. This may decompose into business goals such as winning investors and other stakeholder's confidence in projects that will achieve this reduction, which may then decompose into program or project goals of specific products that will contribute to this reduction. [13] These goals may also be useful in prioritizing stakeholders and their needs using the tools in ISO 16355-4:2017. [3] It was found that the ISO 16355 methods can help bring clarity to complex ‘soft’ issues such as identifying high impact stakeholders, a structured approach to identify and prioritize their needs, and how to transfer these into functional and non-functional requirements for the product.

3.7 Modern Blitz QFD® and SE

Integration of modern Blitz QFD® tools as a front-end to SE requirements management was strengthened in 2016 in conjunction with an aerospace application where SE was viewed as a means of reducing redesign in an environment of increasing demands from customers by "increasing pre-work to decrease rework." While SE worked well for managing the product level solution to stakeholder requirements, there were business level problems and wishes from the directors and executives both inside and outside the company "that are seldom analyzed or written. They may be human expressions with deep meaning and have embedded within them a whole host of requirements that the source may not be aware of." [14] These expressions could be clarified as business goals in the Blitz QFD® process, and these business goals used to map the influences of the various stakeholders and diagram different application contexts and scenarios. These contexts reveal true stakeholder needs and prioritize both functional and non-functional (performance) requirements necessary to fulfil these needs. These were approved at the business sponsor level, and a commitment was made to follow through with the "requirements-led behaviors" that comprise the left-hand side of the SE V-diagram shown in Figure 1.

4. FUTURE OF SE AND QFD INTEGRATION

Early attempts at integration of systems engineering and quality function deployment focused on the use of Comprehensive QFD matrices to transfer the priorities of stakeholder requirements through the decomposition of system level solutions to subsystems, concepts, components, and build processes, with the goal of assuring quality of the product in various scenarios throughout the product life cycle. With the introduction of modern Blitz QFD® and ISO 16355, the integration of SE and QFD has been expanded upstream to better document the strategic and business goals of complex projects, the interactions of various stakeholders, prioritized application scenarios and associated needs, and the functional and non-functional requirements needed to solidify a business definition that will guide the behaviors of the internal and external supply chain, partners, sales, and service.

The International Council on Systems Engineering in the UK has been hosting SE-QFD integration workshops since 2014 for the purpose of creating a roadmap on how these two disciplines can better support the development of large, complex products in less time and with lower cost.

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.

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