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BSI Standards Publication

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

Part 8: Guidelines for commercialization and life cycle

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee MS/6, Methodologies for business process improvement using statistical methods.

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

Part 8: Guidelines for commercialization and life cycle

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

Partie 8: Lignes directrices pour la commercialisation et le cycle de vie

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CH-1214 Vernier, Geneva, Switzerland
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Contents

Page

Foreword ... **vi**
Introduction ... **vii**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Basic concepts of QFD ... **1**
5 Integration of QFD and product development methods ... **2**
5.1 QFD support for product development methods ... 2
5.2 Flow of product development with QFD ... 2
5.3 Customers and stakeholders ... 2
6 Types of QFD projects ... **2**
7 QFD team membership ... **2**
7.1 QFD uses cross-functional teams ... 2
7.2 Core team membership ... 2
7.3 Subject matter experts ... 2
7.4 QFD team leadership ... 2
8 Lifestyle and emotional quality deployment ... **4**
8.1 Kansei engineering ... 4
8.2 Setting product image strategy ... 4
8.3 Identifying stakeholders and customers ... 4
8.4 Visiting customers and stakeholders to understand context of use ... 4
8.5 Interviewing and doing ethnographies to understand customer lifestyle and self-image ... 5
8.6 Deriving lifestyle words with a customer lifestyle table ... 5
8.7 Affinity diagram of lifestyle words ... 6
8.8 Hierarchy diagram of lifestyle words ... 6
8.9 Identifying product attributes and set up experimental trials ... 7
8.9.1 Selecting product concepts to be evaluated ... 7
8.9.2 Creating survey of concepts and lifestyle words ... 7
8.10 Statistical analysis of customers' evaluations of products ... 9
8.11 Deploy to design and development ... 10
9 Component deployment ... **10**
9.1 General ... 10
9.2 Modern Blitz QFD®and the maximum value table (MVT) ... 11
9.3 Functional requirements-components matrix ... 11
9.3.1 Purpose of the functional requirements-components matrix ... 11
9.3.2 Building the functional requirements-components matrix ... 11
9.4 Component-sub-function matrix and value engineering ... 13
9.4.1 Purpose of the component-sub-function matrix ... 13
9.4.2 Building the component-sub-function matrix ... 13
9.4.3 Value analysis (VA) ... 15
9.4.4 Value engineering (VE) ... 16
9.5 Function-subassembly and component matrix ... 17
9.5.1 Purpose of the function-components matrix ... 17
9.5.2 Building the function-component matrix (unweighted) ... 17
9.6 Subsystem-components matrix ... 17
9.6.1 Purpose of the subsystem-components matrix ... 17
9.6.2 Building the subsystem-components matrix ... 18
9.7 Component-failure mode matrix ... 19
9.7.1 Purpose of the component-failure mode matrix ... 19
9.7.2 Building the component-failure mode matrix ... 19
9.8 Component failure mode and effects analysis (FMEA) ... 19

Documents
Document Sharing Hub

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Full document details: PD ISO/TR 16355-8:2017

9.8.1 General ... 19
9.8.2 Risk priority number (RPN) calculation ... 20
9.9 Quality assurance (QA) table ... 24
9.9.1 Purpose of the QA table ... 24
9.9.2 Building the QA table ... 24

10 Production method (manufacturing and process) deployment ... 24
10.1 General ... 24
10.1.1 Objective ... 24
10.1.2 Composition ... 25
10.2 Modern Blitz QFD® and the maximum value table (MVT) ... 25
10.3 Components-manufacturing operations matrix ... 26
10.3.1 Purpose of the components-manufacturing operations matrix ... 26
10.3.2 Building the components-manufacturing operations matrix ... 26

11 Testing, validation, design review, and prototyping ... 27
11.1 General ... 27
11.2 Testing ... 27
11.2.1 Purpose of components-test matrix ... 27
11.2.2 Building the components-test matrix ... 27
11.3 Validation ... 28
11.3.1 General ... 28
11.3.2 Focus groups ... 28
11.3.3 Kano surveys ... 28
11.3.4 Conjoint analysis ... 28
11.4 Design review ... 29
11.5 Prototyping ... 29

12 Production planning ... 29
12.1 General ... 29
12.2 Process capability ... 29
12.2.1 C_p ... 29
12.2.2 C_{pk} ... 30
12.3 Optimize process ... 30
12.4 Make-or-buy decision ... 30
12.5 Project work or task management ... 31

13 Build and process planning ... 32
13.1 General ... 32
13.2 Quality control (QC) process planning table ... 32
13.3 Quality control (QC) tables for component production and assembly ... 33
13.4 Process FMEA ... 34
13.5 Work standards ... 35
13.5.1 QC process table based work standard ... 36
13.5.2 L-matrix based work standard ... 36
13.6 Other tools and methods ... 38

14 Build ... 38
14.1 General ... 38
14.2 Applicable tools and methods ... 38

15 Packaging design, logistics, channel management, consumer information, and operating instructions ... 39
15.1 Functional packaging ... 39
15.2 Aesthetics and packaging ... 39
15.3 Logistics ... 39
15.4 Marketing claims ... 39
15.5 Marketing collateral, operating instructions, service and repair documents, service parts ... 40

16 Customer support ... 40
16.1 General ... 40

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Documents
Document Sharing Hub
Full document details: PD ISO/TR 16355-8:2017

17 Customer satisfaction **41**
17.1 Customer satisfaction surveys 41
17.2 Reporting customer satisfaction results 42
17.3 Tying customer satisfaction results back to project goals 43

18 Product end-of-life disposal, recycle, reuse, and other sustainability concerns **43**

19 Flow to next generation development **45**
19.1 Generational improvements with modern Blitz QFD® 45
19.2 Generational improvements with comprehensive QFD 45
19.2.1 General 45
19.2.2 Updating comprehensive QFD 46

20 Quality assurance network **47**
20.1 Objective 47
20.2 Composition 47

Bibliography **49**

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Documents
Document Sharing Hub
Full document details: PD ISO/TR 16355-8:2017

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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*.

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

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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.

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

Part 8: Guidelines for commercialization and life cycle

1 Scope

This document describes after optimization of product design to address non-functional requirements, for example, test, produce, commercialize, deliver, support, and eventually retire a product from the market and provides guidance on the use of the applicable tools and methods. The goal is to identify and assure key processes and measures in order to satisfy and deliver value to customers and stakeholders. The topics in this document are not exhaustive and vary according to industry, product, and markets. They are considered a guide to encourage users of this document to explore activities needed to accomplish the same goal for their products.

NOTE Some of the activities described in this document can be used at an earlier stage.

Users of this document 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, business process design, and other phases in hardware, software, service, and system organizations.

2 Normative references

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

ISO 16355-1:2015, *Application of statistical and related methods to new technology and product development process — Part 1: General principles and perspectives of Quality Function Deployment (QFD*

3 Terms and definitions

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

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

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

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

4 Basic concepts of QFD

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

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5 Integration of QFD and product development methods

5.1 QFD support for product development methods

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

5.2 Flow of product development with QFD

The flow of QFD methods and tools varies according to the organization and project requirements. Typically, they begin with broad concerns and through prioritization flow down to specifics.

Figure 1[1] shows the flow of product development from quality to technology to cost to reliability deployments. This document begins with components deployment and describes additional analyses that are used in new product development.

5.3 Customers and stakeholders

Stakeholders include external customers and internal members of business and work processes who are also important in development of new products, services, information systems, and processes.

6 Types of QFD projects

QFD projects encompass new developments, as well as generational improvements to existing products. The types of QFD projects are described in ISO 16355-1:2015, Clause 6 and ISO 16355-2:2017, Clause 6 Notes.

7 QFD team membership

7.1 QFD uses cross-functional teams

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

7.2 Core team membership

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

7.3 Subject matter experts

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

7.4 QFD team leadership

QFD team leadership is described in ISO 16355-1:2015, 7.4.

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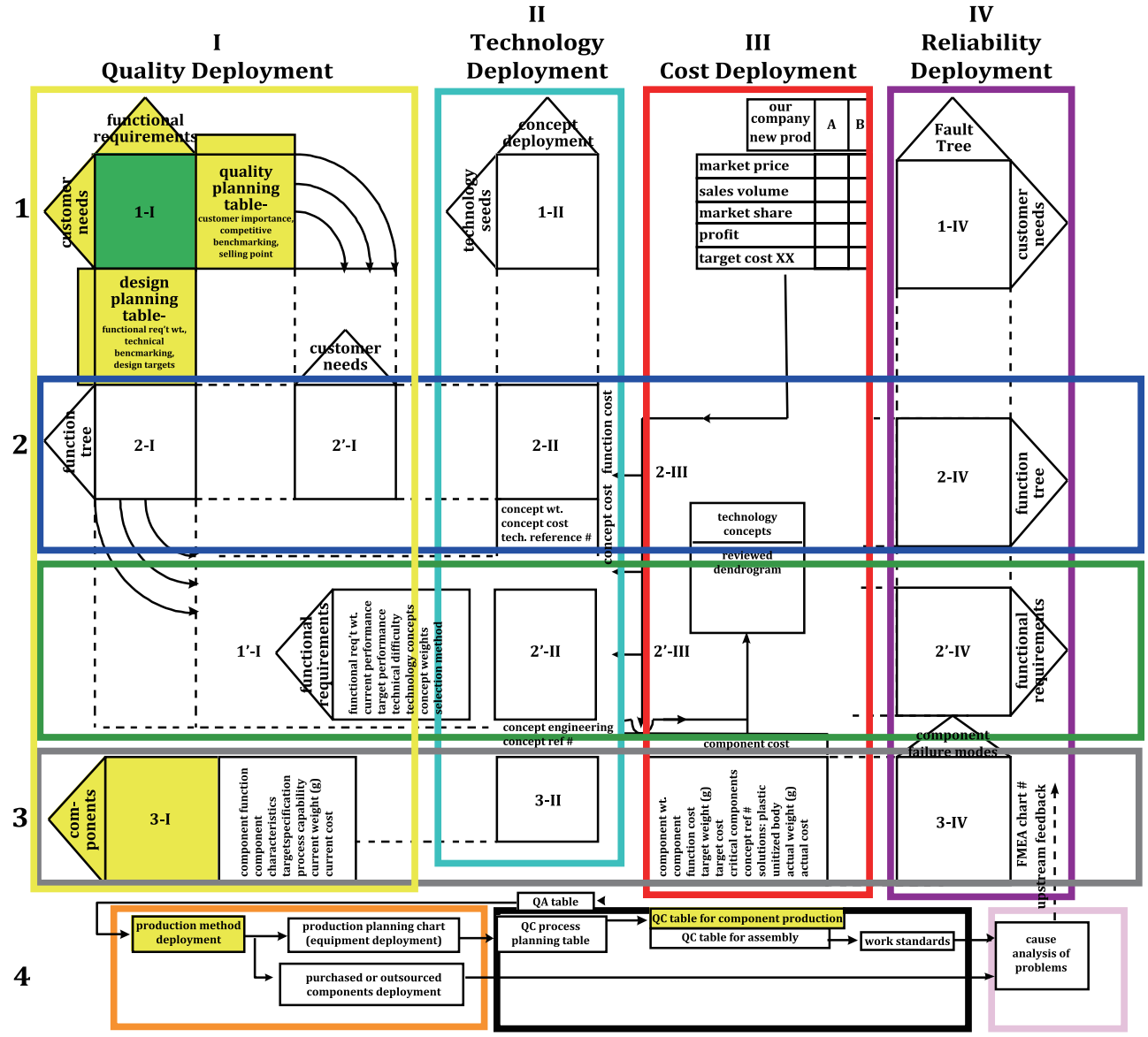

Key

	House of Quality		New Concept Deployment
	4-Phase QFD for part suppliers		Components Deployment
	Quality Deployment		Cost Deployment
	New Technology Deployment		Manufacturing Deployment
	Reliability Deployment		Production Deployment
	Function Deployment		Process Improvement

Figure 1 — Comprehensive QFD

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8 Lifestyle and emotional quality deployment

While QFD focuses on the functional and performance factors of a product, lifestyle and emotional quality deployment focuses on non-functional factors such as aesthetics, attraction, and sensory responses to a product, its packaging, and its branding. Many products from fashion to industrial products can convey pride in ownership through these factors that lead to brand loyalty, repurchase, and recommendation to others. Consideration of these factors early in the design phase can lead to individualistic configurations that address customer lifestyle and emotions with little cost impact to the maker. One approach that has been long integrated into the QFD process is called Kansei engineering[30].

8.1 Kansei engineering

Originally developed as a human factors approach to engineer an appealing product by addressing how people interpret inputs from the five physical senses of sight, sound, taste, touch, and smell, Kansei engineering now bridges the traditional industrial design, marketing, and engineering functions[6]. Lifestyle deployment uses the following steps:

a) set product image strategy;

b) identify stakeholders and customers;

c) visit customers to understand context of use;

d) interview and do ethnographies to understand customer lifestyle and self-image;

e) derive lifestyle words with a customer lifestyle table;

f) have target customers create an affinity diagram to structure lifestyle words and extract product meta-metaphor;

g) make a hierarchy diagram translating lifestyle words into the five senses;

h) identify product attributes and set up experimental trials;

i) have customers quantify lifestyle words with product samples and images; conduct statistical analyses of which design attributes best explain customer lifestyle words;

j) deploy to design and development.

8.2 Setting product image strategy

Product image should support the brand strategy of the organization. Brand strategy, as with other strategic initiatives, is described in ISO 16355-2. It should consider trends in market and sales, technology, fashion and style, and other preferences.

8.3 Identifying stakeholders and customers

Brand strategy is customer specific according to such demographics as age, sex, culture, geography, occupation, and other factors. The customer segments table described in ISO 16355-2 can be modified to include these factors.

8.4 Visiting customers and stakeholders to understand context of use

Lifestyle is communicated through words, behaviour, body language, and physiological responses. The gemba visit team should include industrial and fashion design, marketing, brand management, retail sales, merchandising, and engineering. Setting up and conducting customer gemba visits where they work and play are described in ISO 16355-2. The gemba visit table described in ISO 16355-2 can be modified to clarify emotional and lifestyle words such as beautiful, powerful, cute, and elegant.

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8.5 Interviewing and doing ethnographies to understand customer lifestyle and self-image

Customers and stakeholders are interviewed to discuss their lifestyle choices, preferences, aspirations, motivations, and other matters related to how they wish to appear to others and how they think about themselves. Depending on who the customer is, what his or her peer group values, what advertising message is conveyed (direct ads, product placement in movies, etc.), fads and favourites are constantly changing, creating opportunities for new product excitement and differentiation. Ethnographies help understand the values, beliefs, wishes, dreams, self-image, projected image, future, past cultural positives and negatives about the targeted segment. This psychological profile of the segment is dynamic, and ethnographies are updated frequently to keep information fresh.

EXAMPLE Sample ethnography questions for lifestyle deployment for office wear.

a) What is your biggest opportunity, concern, challenge, difficulty?

b) Who in your life do you relate to most? Who is your favourite politician or movie star?

c) What event in the last 6 months has affected you the most?

d) What does your clothing say about you?

e) What clothing article do you care most about and why?

f) How much time do you spend selecting clothes?

g) What brands do you like to buy and why?

h) How long do you usually wear clothes in terms of hours, seasons, years?

8.6 Deriving lifestyle words with a customer lifestyle table

The gemba visit table clarifies lifestyle items and ethnographic responses should then be arranged in a customer lifestyle table (CLT), as shown in Table 1. The CLT attempts to parse and make sense of the somewhat random language in the ethnographies and translate them into lifestyle words[27].

Table 1 — Customer lifestyle table for office wear

I am a [who] going to [where] in the [when] because I like to [what activity] because it makes me feel [why]; so I want [how product fulfils], and therefore I usually buy [which brand].

Who	Where	When	What activity	Why	How product fulfils	Which brand	Lifestyle words
Urban Uptown, Money and Brains	Work at the client's place of business	Year-round	I like to lead people and projects.	Many years of experi-ence have led to promi-nence in my field. I am respected and expect-ed to teach others.	My clothing should be subtle and distinc-tive. My ties should exude power without pretension.	Therefore I buy Kenneth Cole.	Leader, experienced, prominent, smart, respected, teacher, power, subtle, distinctive

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8.7 Affinity diagram of lifestyle words

The affinity diagram process is described in ISO 16355-4. Additionally, the affinity diagram should include a meta-metaphor statement that describes the most abstract lifestyle or emotional ideal. This ideal is sometimes used as an advertising tagline.

EXAMPLE Mazda Motor Corporation™[1)] in the design of the MX-5 (Miata) employed the meta-metaphor "horse and rider as one" to personify that the automobile was a natural extension of the driver's mind and body and that they performed as if a single organism.

8.8 Hierarchy diagram of lifestyle words

The hierarchy diagram process is described in ISO 16355-4. In lifestyle deployment, the hierarchy diagram is inserted into a table that includes the sensory organ affiliated with the lifestyle word and the product system or subsystem and the design elements and quality characteristics of the components that interface with the sensory organ. After the analysis is completed, a target performance value or specification for characteristics of the component is added.

EXAMPLE Table 2 shows the flow of information from the meta-metaphor to the sensory organ to the pen system, design, and quality characteristics. In the lifestyle domain, "Words that draw attention" is the desired image of the target customer (engineering consultant) who wants to be seen by her clients as elegant, responsive, and sophisticated. Her pen should be beautiful, well designed, yet warm and curvy. These lifestyle words are sensed through sight and touch. The physical domain includes pen systems such as the body and clip, with design elements and quality characteristics of body dimensions such as length of pen and clip design such as clip materials.

Table 2 — Lifestyle words hierarchy diagram for pen

Lifestyle domain				Physical domain			
Meta-metaphor	Primary	Secondary	Sense	System	Design element	Quality characteristic	Target specification
"Words that draw attention"	elegant	beautiful	sight	body	body dimension	length	
		good design	sight	clip	clip design	clip materials	
		warm	feel	body	body design	body colour	
		curvy	touch	body	body dimension	curvature	
	responsive	feels easy to use	touch	body	balance	centre of gravity	
		looks easy to write with	sight	tip	shape	roundness	
	sophisticated	expensive looking	sight	body	body design	body materials	
		high class	sound	mechanism	protractor/retractor characteristics	audibility of click	
		modern	sight	body	body dimensions	volume (diameter)	
		thick	sight	ink	ink characteristics	optical density	

1) MX-5 (Miata) is the trade name of a product supplied by Mazda Motor Corporation. This information is given for the convenience of the users of this document and does not constitute an endorsement by ISO of this product.

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8.9 Identifying product attributes and set up experimental trials

The quality characteristics and the lifestyle words in the hierarchy diagram are used as the product attributes to be tested. The results of the trials are statistically analysed to identify which lifestyle words are preferred by the customers and which product attribute best explains this preference.

NOTE If too many attributes are tested, the effort asked of the customer to evaluate can increase substantially.

8.9.1 Selecting product concepts to be evaluated

Product concepts are evaluated by the customers while experiencing the concepts with the appropriate senses. Concepts can be actual products, images of products, or unrelated products that share similar attributes[15]. Each product attribute performance level is exhibited at least twice in the selected product concepts.

NOTE If too many concepts are tested, the effort asked of the customer to evaluate can increase substantially.

EXAMPLE Figure 2 illustrates three product attributes (length, volume, colour) at different levels of performance (short-long, thin-fat, and red-blue-black-silver). There are three short pens and six long pens, four thin pens and five fat pens, and two red, two blue, two black, and three silver pens. Pen #1 is long, thin, silver, and so forth.

length (3 short, 6 long)	long	long	long	long	short	short	long	long	short
volume (4 thin, 5 fat)	thin	thin	thin	fat	fat	fat	fat	fat	thin
colour (2 red, 2 blue. 2 black, 3 silver)	silver	silver	blue	black	black	silver	blue	red	red

Figure 2 — Pen concepts and product attributes

8.9.2 Creating survey of concepts and lifestyle words

Customers are asked to evaluate each product concept against each lifestyle word in a survey. Because the lifestyle words are more emotional than functional, a more psychologically friendly survey method, the semantic differential, is recommended[32]. The semantic differential survey uses polar opposite adjectives along a 5- or 7-level scale, with the upper levels expressing the more desired adjective. The opposite words are antonyms or "not" constructions, with the latter considered a bit more neutral

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sounding but less likely to be misinterpreted. Examples of antonym polar opposites include hot-cold and expensive-cheap. Examples of "not" constructions include hot-not hot and expensive-not expensive.

EXAMPLE 1 The following 10 polar word pairs were used in a semantic differential survey. Customers were instructed to view the sample pens in Figure 2 and respond on a 1 to 5 scale (5 being most desired) according to how they felt about each pen. The results were recorded in a response grid in a statistics app.

1. Beautiful	5–4–3–2–1	ugly
2. Good design	5–4–3–2–1	bad design
3. High class	5–4–3–2–1	low class
4. Modern	5–4–3–2–1	conservative
5. Curved	5–4–3–2–1	straight
6. Thick	5–4–3–2–1	thin
7. Easy to use	5–4–3–2–1	hard to use
8. Easy to write	5–4–3–2–1	hard to write
9. Warm	5–4–3–2–1	cool
10. Expensive	5–4–3–2–1	cheap

EXAMPLE 2 See Figure 3 for the result of a customer's evaluation of pens. For beautiful vs. ugly, the customer felt that pen #1 was a 3 on the 1 to 5 scale, pen #2 was a 2, pen #3 was a 2, pen #4 was a 5, and so forth for each pen and each lifestyle word pair.

1. Beautiful	5–4–3–2–1	ugly	3	2	2	5	1	2	1	4	4
2. Good design	5–4–3–2–1	bad design	5	4	1	4	2	5	2	4	4
3. High class	5–4–3–2–1	low class	3	3	2	5	3	3	2	2	4
4. Modern	5–4–3–2–1	conservative	5	5	3	3	4	5	1	4	3
5. Curved	5–4–3–2–1	straight	2	3	4	4	4	3	5	5	4
6. Thick	5–4–3–2–1	thin	3	4	2	4	5	5	2	5	4
7. Easy to use	5–4–3–2–1	hard to use	4	4	3	4	4	4	1	4	3
8. Easy to write	5–4–3–2–1	hard to write	5	3	3	4	4	4	1	5	2
9. Warm	5–4–3–2–1	cool	4	2	4	5	4	2	3	4	5
10. Expensive	5–4–3–2–1	cheap	4	2	2	5	3	5	4	4	4

Figure 3 — One customer's evaluation of pens per each lifestyle word

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8.10 Statistical analysis of customers' evaluations of products

The survey is fielded to pre-qualified customers within the segment identified in 8.3. The sample size of respondents should reflect the confidence intervals as described in ISO 16355-4. All responses are entered into a statistical app worksheet aligned to the attributes in the trials in Figure 2. Statistical analyses include factor analysis, principal component analysis, and bivariate correlations to identify which lifestyle words best reflect the customer's lifestyle, which product quality characteristic best explains the lifestyle word, and which performance level is preferred.

NOTE Survey sample size can be affected by the number of concepts, number of lifestyle words, number of attributes, and number of levels of each attribute. The larger the number of words and levels, the larger the sample needed. Studies with five concepts, five lifestyle words, three attributes at two levels each were conducted with as few as 60 participants.

EXAMPLE 1 In Table 3, the lifestyle words are entered in the columns and evaluations of the nine pens are shown in the rows. To the right of the responses are the trials describing the attributes given in Figure 2. This particular statistical app requires that length be expressed as a 1 for short or 2 for long, as well as a 0 (off) for l1 and 1 (on) for l2 if the pen is long. In this example, pen #1 is long, thin, and silver as indicated in Table 3.

Table 3 — Survey responses for pen entered into a statistical package worksheet

Semantic differential lifestyle words | Length and levels | Volume and levels | Colour and levels

Responses | Trials

Beautiful	Good_design	High_class	Modern	Curved	Thick	Easyuse	Easywrite	Warm	Expensive	length	l1 (short)	l2 (long)	volume	v1 (thin)	v2 (fat)	colour	silver	blue	black	red
3	5	3	5	2	3	4	5	4	4	2	0	1	1	1	0	1	1	0	0	0
2	4	3	5	3	4	4	3	2	2	2	0	1	1	1	0	1	1	0	0	0
2	1	2	3	4	2	3	3	4	2	2	0	1	1	1	0	2	0	1	0	0
5	4	5	3	4	4	4	4	5	5	2	0	1	2	0	1	3	0	0	1	0
1	2	3	4	4	5	4	4	4	3	1	1	0	2	0	1	3	0	0	1	0
2	5	3	5	3	5	4	4	2	5	1	1	0	2	0	1	1	1	0	0	0
1	2	2	1	5	2	1	1	3	4	2	0	1	2	0	1	2	0	1	0	0
4	4	2	4	5	5	4	5	4	4	2	0	1	2	0	1	4	0	0	0	1
4	4	4	3	4	4	3	2	5	4	1	1	0	1	1	0	4	0	0	0	1

EXAMPLE 2 The principal components analysis extraction in Table 4 indicates that MODERN has the most variation in common with the other variables. The higher the number in the extractions column, the more communality it has.

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Table 4 — Principal component analysis communalities

Communalities

	Initial	Extraction
Beautiful	1,000	0,827
Good_design	1,000	0,913
High_class	1,000	0,645
Modern	1,000	0,986
Curved	1,000	0,625
Thick	1,000	0,520
Easyuse	1,000	0,977
Easywrite	1,000	0,802
Warm	1,000	0,859
Expensive	1,000	0,762

Extraction Method: Principal Component Analysis.

EXAMPLE 3 A bivariate correlation is run to determine which levels of each quality characteristic best explain MODERN. Table 5 shows that a short (l1), thin (v1), silver pen has the highest correlations to MODERN for the target customer segment.

Table 5 — Bivariate correlation

		modern	l1	l2	v1	v2	silver	blue	black	red
modern	Pearson correlation	1	0,189	−0,189	0,239	−0,239	0,756	−0,714	−0,071	−0,071
	Sig. (2-tailed)		0,626	0,626	0,536	0,536	0,018	0,031	0,855	0,855
	N	9	9	9	9	9	9	9	9	9

8.11 Deploy to design and development

Based on the above analysis, more specific shortness, thinness, and silver variations can be prototyped and further tested with target customers. The use of lifestyle deployment for packaging is discussed in Clause 15.

9 Component deployment

9.1 General

Once the functional and performance requirements of the high level design have been optimized as described in ISO 16355-5, ISO 16355-6, and ISO 16355-7 and non-functional requirements (aesthetics, lifestyle, emotional quality) have been examined as described in Clause 8, the design should continue to be analysed to the component level. A series of L-matrices and tables deploy quality, technology, cost, reliability, and other factors from the high level design to the component level.

NOTE According to the product, components can be specific parts or assemblies of parts from the bill of materials of a physical product[36], ingredients of a processed food or chemical product, human tasks in a service product, or objects, entities, or lines of code in a software or information technology product.

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