

Application of Quality Function Deployment (QFD) to Print Quality Assessment Activities

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Abstract

The most important mission of a print quality program is to ensure that the print quality customers demand is designed into the finished product. To accomplish this, a print quality program must perform five tasks: (1) understand customer requirements; (2) assess objective print quality; (3) relate customer requirements to objective measures; (4) set tolerance limits; and (5) benchmark the competition.

Individually, these five tasks generate a wealth of information useful in marketing and engineering decision-making. However, it is even more effective to organize these tasks into a single unified framework. The results can be surprising. Relationships between seemingly unrelated tasks can be identified; critical items become more obvious; and places where tradeoffs can be made become apparent. This paper describes how the technique of quality function deployment (QFD) can unify these five print quality tasks, thereby catalyzing beneficial interactions among marketing, engineering, and print-quality organizations.

Introduction

A comprehensive print quality effort should comprehend a wide range of activities, ranging from understanding customer requirements to aiding in product definition. Common print quality group activities include the development of objective metrics; measurements of the physical attributes of print samples; subjective evaluation of print quality; development of systems-level print quality specifications; participation in marketing research; and benchmarking of competitive products.

Individually, each of these activities yields a wealth of information. Indeed, the sheer quantity of print quality information often overwhelms decision-makers. Thus, it is desirable to organize the gathered data into a systematic framework from which actionable goals can be derived.

Furthermore, in order to contribute effectively to product development and marketing efforts, a print quality group must interact with marketing and engineering organizations. The marketing organization provides definitions of target markets and collaborates to establish customer print quality requirements. In turn, data generated by the print quality organization on competitive benchmarking are invaluable information to marketing. The print quality organization provides the engineering organizations with a set of tools or services to objectively

measure physical print quality attributes. Such tools or services enable engineers to conduct experiments to examine relationship between design variables and print quality. A systems-level print quality specification is another deliverable from the print quality group to the engineering organization. Again, to facilitate interactions among the marketing, engineering and print quality organizations, a unifying framework for all print quality data is desirable.

Quality function deployment (QFD) is one such means of organizing print quality data for decision-makers and enabling effective information flow among the marketing, engineering and print quality organizations.

QFD

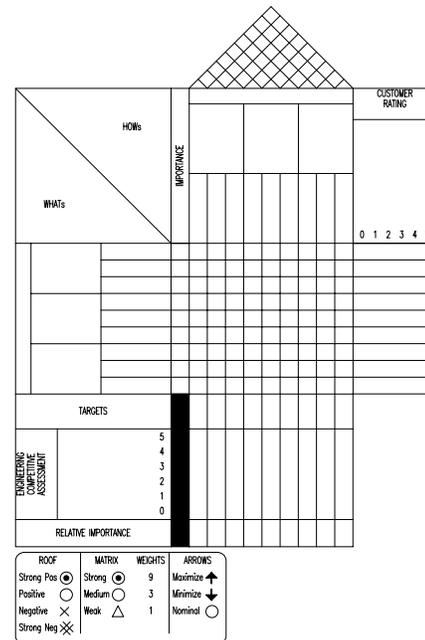


Figure 1: House of Quality

QFD is a process widely used to translate customer needs into the technical requirements a company can use in research and product development, engineering, manufacturing, marketing, sales and distribution (1). It

provides a framework for identifying and collecting needed data and allows for its systematic deployment in decision-making. In other words, it enables marketing and engineering decisions based on customer requirements, engineering, manufacturing and marketing constraints and competitive benchmarking.

QFD is frequently recognized by its use of the "house of quality" diagram, a graphical summary of how customer requirements relate to objective measures. Figure 1 shows a house of quality. It consists of multiple rooms, in which data such as customer requirements, objective measures, tolerance limits, competitive benchmarking are organized and related to one another.

Applying QFD to Print Quality Activities

There are five tasks a print quality group must perform: (1) understand customer requirements; (2) assess objective print quality; (3) relate customer requirements to objective measures; (4) set tolerance limits; and (5) benchmark the competition. These tasks lend themselves well to a framework provided by the QFD process. What follows describes how QFD can unify these five categories of print quality.

Understanding Customer Requirements

The first step in the print quality effort for new product development or upgrading is to understand the target markets and customers' needs and wants regarding quality of printed materials. The QFD process starts with collection of the "voice of customers."

This process is best accomplished by collaborative efforts with the marketing organization. First, the target market must be defined; then marketing research must be conducted to establish customer requirements. Customer requirements can be obtained through:

- Observational studies
- Qualitative studies such as focus groups and interviews
- Secondary data available from market research firms.

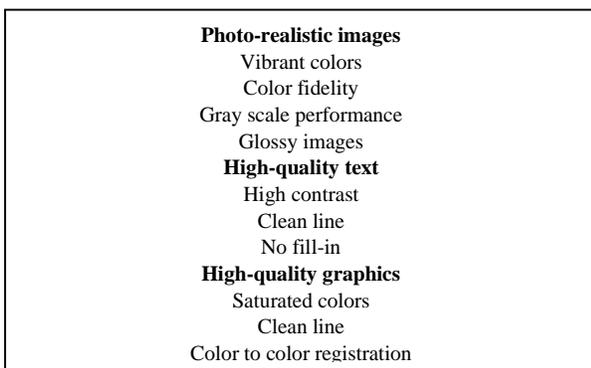


Figure 2: Sample of Customer Requirements

Customer input via focus groups and interviews is often vague and difficult to implement. Since participants in the qualitative studies are rooted in the present, they are not

likely to express what they will want in future. As a consequence, it is often impossible to know exactly what customer requirements will be at product launch. This shortcoming must be recognized and augmented by other data sources.

Figure 2 shows an example list of customer print quality requirements.

Objective Print Quality Assessment

The second step in the QFD process is to establish the objective measures a company can utilize in product development. Objective print quality assessment starts with the effort to identify the physical characteristics of print samples that relate closely to those subjective print quality attributes customers care most about.

Once identified, one needs to develop metrics and procedures to measure and analyze the physical characteristics of print samples objectively and repeatedly. Objective measures must not specify a single technology solution such as the type of coating on the media or screening algorithm. Figure 3 shows a sample list of objective print quality measures.

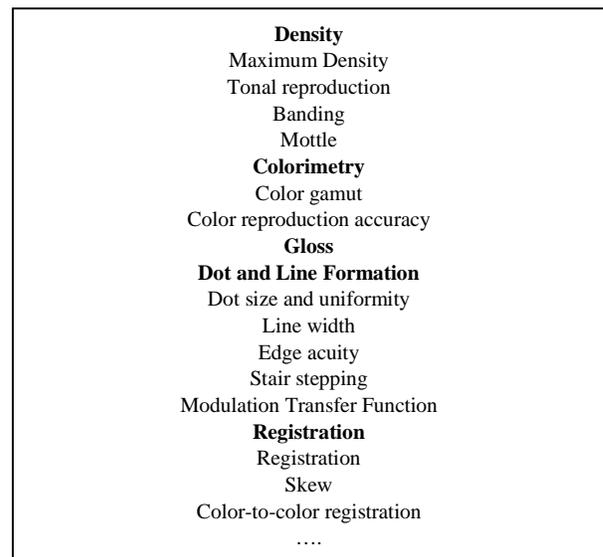


Figure 3: Sample of Objective Measures

Relating Customer Requirements to Objective Requirements

The third activity of the QFD process is to translate customer requirements into actionable objective requirements. This is simply done by associating customer requirements and objective measures identified in the first two steps of the QFD process. Figure 4 shows an example of relationships linked in this manner.

As seen in Figure 4, customer requirements often relate to more than one objective measure. In order to clarify complex relationships between customer requirements and objective measures, QFD utilizes a relational matrix as seen in Figure 5. A double circle indicates a strong relationship, a single circle a medium-strength relationship and a triangle

a weak relationship.

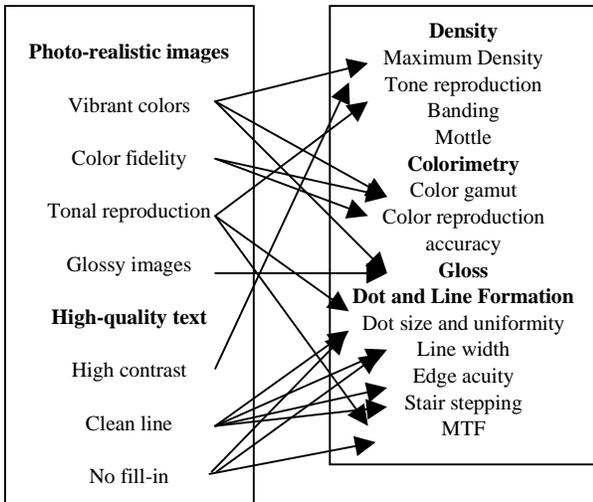


Figure 4: Relating Customer Requirements to Objective Measures

HOWs		Objective Print Quality												
		Density			Colorimetry		Gloss		Dot and Line Formation			Registration		
WHATs		max. density	TFC	bending	mottle	color gamut reproduction occur	gloss (60 degrees)	dot size	dot uniformity	line width	edge acuity	stair stepping	MTF	color registration
Photo-realistic image	vibrant colors	●				●								
	color fidelity		●			●								
	gray scale		●					○	○					
High Quality Text	glossy images						●							
	high contrast	●												
High Quality Graphics	clean lines							△	○	●	●			
	no fill-in							△	○				●	
	uniform solid					●								●

MATRIX WEIGHTS ARROWS

Strong ● 9 Maximize ↑

Medium ○ 3 Minimize ↓

Weak △ 1 Nominal ○

Figure 5: Relationship Matrix

Setting Tolerance Limits

The next step in the QFD process is to set a tolerance limit for each objective measures so as to satisfy customer requirements. A collection of the tolerance limits for objective print quality measures is a print quality specification. The tolerance limits can be set via:

- Subjective assessment
- Competitive benchmarking
- Expert opinion.

Expert opinion is a quick and often reliable way to set tolerance limits. The shortcoming of this approach is that the voice of customers is not reflected in the resulting specification. Technical benchmarking of competitive products yields valuable data for specifying print quality requirements. For example, a tolerance limit can be set as better than the performance of all competitive products; however, customer requirements are not directly used to define specifications.

Subjective print quality assessment is the most desirable method for setting tolerance limits. Some of the questions to be addressed in subjective print quality assessment studies are:

- What level of artifacts may go undetected?
- How well must a printer print or material perform for people to detect improvement in print quality?
- What level of defects/artifacts are accepted or tolerated by a given market?
- What level of a given quality attribute is desirable for the target market?

There are two methodologies for assessing image quality subjectively. The first methodology is psychophysics experiments, used to examine one's sensory and perceptual capabilities to detect, recognize and discriminate among physical stimuli, such as intensity of light, contrast, and colors. One presents stimuli to subjects and asks them whether they can detect any stimuli, compare the magnitude of two stimuli or estimate the magnitude of a stimulus against a standard. The past two centuries of psychophysics research provide a bounty of extant data on human visual perception. For example, the contrast sensitivity function is often used to set tolerance limits in image noise (2).

HOWs		Objective Print Quality												
		Density			Colorimetry		Gloss		Dot and Line Formation			Registration		
WHATs		max. density	TFC	bending	mottle	color gamut reproduction occur	gloss (60 degrees)	dot size	dot uniformity	line width	edge acuity	stair stepping	MTF	color registration
Photo-realistic image	vibrant colors	●				●								
	color fidelity		●			●								
	gray scale		●					○	○					
High Quality Text	glossy images						●							
	high contrast	●												
High Quality Graphics	clean lines							△	○	●	●			
	no fill-in							△	○				●	
	uniform solid					●								●

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Figure 6: House of Quality with Product Specifications

The second methodology involves controlled experiments to examine more complex cognitive judgments. Rating, paired comparison, ranking, category scaling and magnitude estimation are often used to understand the acceptability of image defects or the preference for specific print characteristics (3).

Figure 6 shows a house of quality with tolerance limits. The four steps described above constitute the main body of the QFD process.

Competitive Assessment

Print quality efforts often involve benchmarking competitive products. By understanding the performance of competitive products, engineering and marketing organizations often derive performance targets for the products under development.

QFD provides a means of relating competitive benchmarking results to customer requirements and objective measures. Two types of competitive assessment results can be included in the house of quality: customer assessment and technical assessment. Customer assessment is a measure of how well competitive products are perceived with regard to each customer requirement. Technical assessment measures how well competitive products perform on each objective measure. Figure 7 shows the house of quality with competitive assessment results.

often results in larger dot size variations. Achieving small single pixels can therefore mean a trade-off in dot size uniformity.

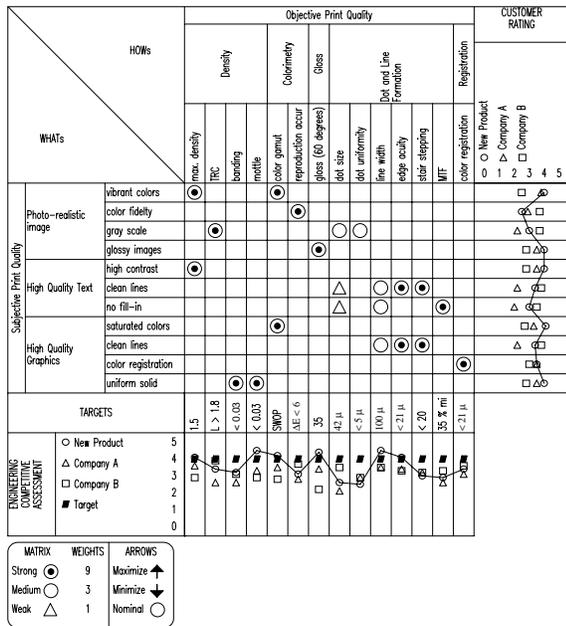


Figure 7: Putting Competitive Assessment Results

Defining Relationships among Objective Measures

The physical attributes of print quality often are correlated negatively. That is, improving performance on one attribute results in the deterioration of another attribute. For example, trying to print single pixels in smaller sizes

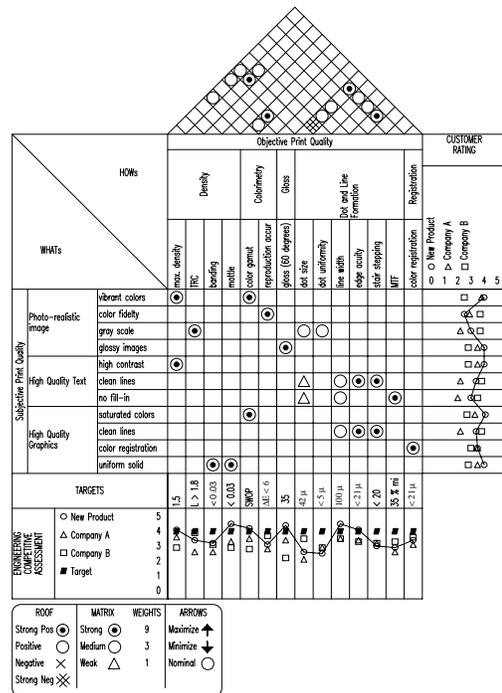


Figure 8: Relationship among Objective Measures

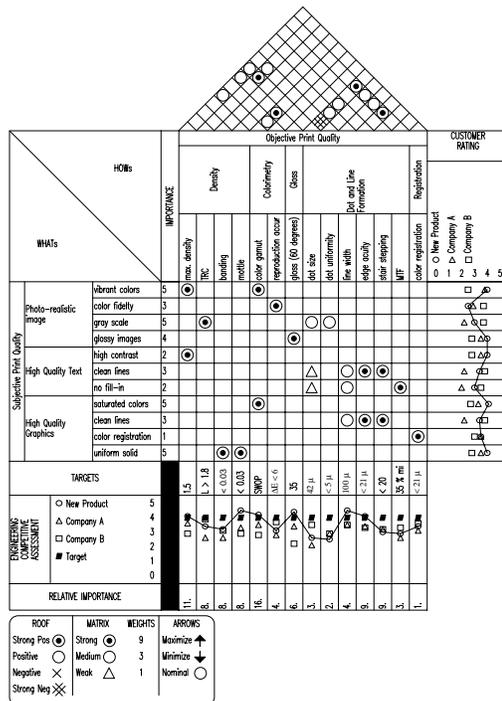


Figure 9: Importance Rating

The QFD process often includes a correlation matrix to aid in identifying potential tradeoffs. Tradeoffs signal further action items for the R & D team and engineering or marketing decisions. Figure 8 shows the house of quality with a correlation matrix. A double cross indicates a strong negative relationship, that is, a tradeoff; a single cross indicates a moderate negative relationship; a single circle indicates a moderate positive relationship; and a double circle a strong positive relationship.

Importance Rating

Lastly, print quality efforts often face the challenge of assigning weights to objective measures according to their importance in order to help the engineering organization prioritize development efforts. The QFD process provides a platform for performing this task. In market research, customers are asked to indicate the relative importance of customer requirements. By using relationship strength between customer requirements and objective measures, one can derive an importance rating for the objective measures as seen in Figure 9.

Summary

The QFD process provides a useful means of organizing the data generated by print quality assessment activities. It

enables the efficient collection of information and its use in print quality decision-making. QFD also eases the difficult task of prioritizing print quality attributes. Further, the QFD process can be extended to deal with relationships between print quality attributes and cost, reliability and speed.

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