The contribution of the QFD methodology for a customer- and market-oriented product planning and development process at IBA Dosimetry

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Abstract

Quality Function Deployment (QFD) describes a general methodology for customer- and market-oriented development for products and services. Key to successful QFD is the separation of the customer requirement (why it is needed) of the technical functions of the product (what it must be or do). There can be no assurance of a quality product without identifying the right customers and discovering their real expectations for that product. There are always uncertainties at answering how customers' expectations should be met, or how the products shall function to meet them. This paper describes the contribution of the QFD methodology as a structured product planning and development tool to minimize the uncertainties mentioned above. It will be shown, by applying QFD on a real project at IBA Dosimetry in Schwarzenbruck, Germany, that the integration of the prioritized customer needs and translation into the language of the developers (the product quality characteristic), "fitness for use" increases. The introduction of the QFD requires considerable effort during the start-up phase. If the method, however, is correctly implemented once, the application can represent a great enrichment for the

company as the company continues to use QFD on future projects. Whether QFD is successful depends, to a large extent, on how the QFD method is tailored to the company circumstances such as: the willingness of the employees to learn, the experience of the employees with the method, and the existing degree of cooperation and communication. The IBA Dosimetry project will explain how these circumstances can be optimized for QFD success.

About the Company

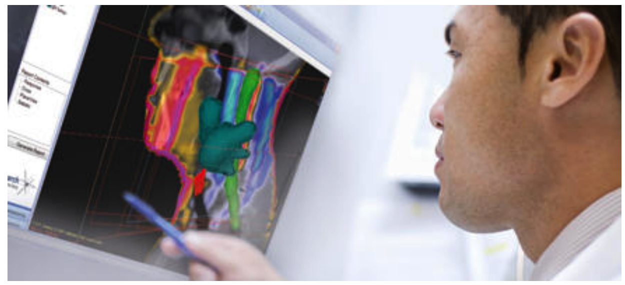


Figure 1 IBA Dosimetry quality assurance software

IBA Dosimetry GmbH, Schwarzenbruck-Germany focuses on the development and supply of dosimetry solutions (Figure 1) for Quality Assurance of medical equipment and increased patient safety, as well as particle accelerators for medical and industrial applications. Headquartered in Belgium and employing more than 1,000 people worldwide, IBA currently has installed systems across Europe and the US and is expanding into emerging markets. The company is focused on building sustainable global growth for investors by providing solutions in the fight against cancer.

The Need for QFD

IBA Dosimetry, for the last fifteen years, has faced a quantum leap in the radiation therapy world we serve; technologies available to treat cancer have advanced rapidly and at a continuously growing pace. This has led to two fundamental challenges – our product portfolio must adapt radically and much more quickly to bring the right products for these new radiation therapy techniques. If changing customer requirements were not clear, comprehensive, and quickly addressed, products release delays would negatively impact time to market and winning in the marketplace.

Though we recognized our problem, we struggled with different approaches and ideas for solving it - none of these seemed to give the results we hoped in understanding what we called the “fuzzy front end” of market requirements. This pressured the development teams to play catch up, and the lost time and energy negatively impacted quality. Our dilemma was clear: what does it take to accelerate the development of really innovative solutions in a medical device environment, while bringing more quality to the end product with solutions that appeal greatly to our customers.

This brought us to QFD as a solution to giving the proper response to both quality and speed. Particularly, the Blitz QFD® (Jayaswal and Patton 2006) approach gave us a faster, better way to understand and communicate throughout the organization, the top three to five customer needs that were a necessary condition for making great products. Now in our second year of using QFD, we are confident that it is the answer to our quality and speed dilemma. This paper will discuss our early experiences share challenges we face to deploy it properly within the IBA organization.

What is QFD?

Quality Function Deployment (QFD) (Mizuno and Akao 1994) describes a general methodology for customer- and market-oriented development for products and services. QFD was developed in Japan in the 1960s (Akao and Mazur 2003) and was first brought to the West in 1983 (Kogure and Akao 1983). While initial applications were in the automotive industry, the healthcare community was quick to pick it up. GOAL/QPC, a leading quality training and research organization in the U.S. formed a Heath Care Applications Research Committee to explore how Total Quality Management and process improvement methods and tools could be used in the health care sector. Their QFD Research Committee proposed conducting pilots at several hospitals and sent instructors to train and facilitate them. These included Bethesda with Cincinnati OH physicians practicing there, Bryn Mawr Hospital in their Philadelphia PA emergency room, New England Memorial Hospital on their Stoneham MA rehab center, and the University of Michigan Hospitals and Health Centers on their new medical procedures unit. Glenn Mazur was designated as the QFD expert for UMHHC, which produced breakthroughs in medical unit start-ups, continuing medical education, and marketing communications to referring physicians (Ehrlich and Hertz 1993). Applications to medical equipment and devices also show the value of both classical QFD methods and the above mentioned Blitz QFD® which will be described in greater detail (Talbot et al 2011).

Key to successful QFD is the separation of the customer need (why it is needed) from the functional requirements of the product (what is must be or do). (Mizuno and Akao 1994, p. 337) Further, there can be no assurance of a quality product without identifying the right customers and discovering their real expectations for that product. This will help reduce the uncertainties in answering to what degree customers' expectations should be met, and how the products shall function to meet them.

This separation of customer needs and functional requirements helped us to better understand:

- That innovative products at an attractive price strongly help position a company for tough market competition.
- That the product must, on the one hand fulfill customer needs, and on the other hand, production costs must remain manageable.

Nevertheless, we learned that fulfilling customer needs is not so simple. Who actually knows which functional requirements of the product are or are not important? In the past, we debated internally what are the exact customer requirements, how can the requirements be quantified, and how could the requirements be connected with the company's technology roadmap. Because of these uncertainties and endless debates, the translation of the customer needs into corresponding product features was not always ensured, and product design, customer needs, and product properties did not always align. To get out of this dilemma, it was necessary to question our current development process in detail:

1. Should we use customer surveys?
2. Are our product designs based on comprehensive market research?
3. Do we register customer wishes and customer expectations systematically?
4. Are we assessing product ideas and product designs systematically?
5. Do we employ a method for a customer-oriented product design?

Unfortunately, all of these questions couldn't be answered clearly positively. Based on our negative results, we concluded that our:

- Product Creation Process (PCP) of the company should be redesigned.
- The QFD methodology should be introduced and integrated into different stages of the PCP.

Redesigning the Structure of IBA Dosimetry Product Creation Process (PCP)

Our Product Creation Process follows the Stage-Gate™ methodology (Cooper 2011, Mazur 2010). Each stage (I – V) corresponds to a well-defined set of activities to be handled as well as a set of deliverables to be produced. A stage is concluded by a gate review during which a set of gate criteria (G0-G5) are conditionally evaluated for the project to move forward to the next stage; this go/kill decision should be seen as a business decision. In parallel to these gates, a number of quality assurance (QA) check point reviews (Rx) will evaluate the project deliverables from a regulatory standpoint. The successful review at these QA check points is one of the criteria to be evaluated during the gate decision. Figure *2* shows our tailored Stage-Gate™ flow with added regulatory reviews (R1-R6).

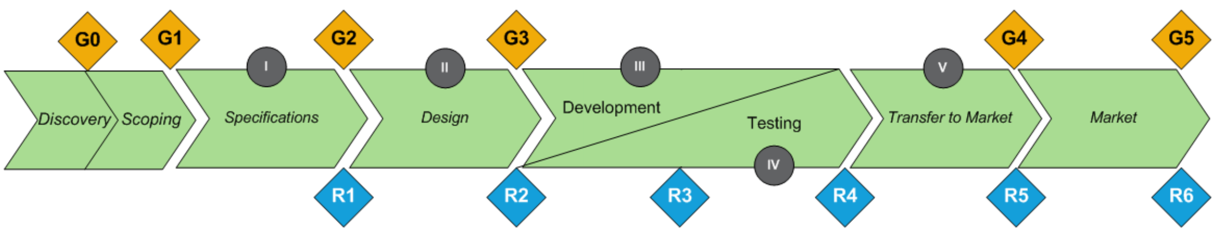


Figure 2 Product Creation Process flow

Our Product Creation Process can be further subdivided into three main sets of activities – 1) front end for innovation and discovery, 2) product realization, design and development, and 3) launch. These activities flow into each other as illustrated in Figure 3.

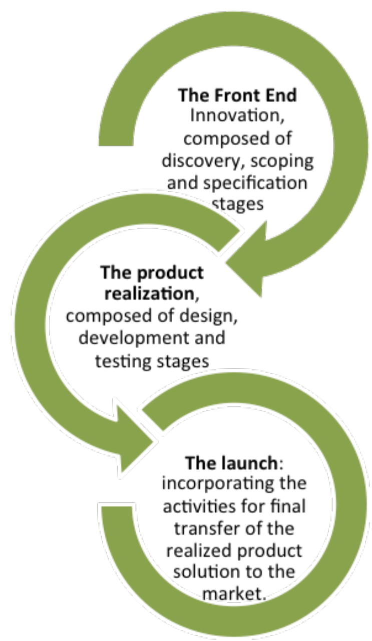


Figure 3 PCP activities

Integrating QFD into our PCP

Given the complexities of our products and our Product Creation Process, it was imperative that we integrate QFD to achieve these outcomes:

1. Improved market success as measured by market share and revenue, built upon "fitness for use" by our customers.
2. Buy-in from employees as measured by improved com-

munication and cooperation.

Our first attempt was the widely known 4-Phase approach to QFD that emerged in the 1980s U.S. automotive supplier market where "build-to-print" specifications were supplied by an original equipment manufacturer (OEM). This proved inappropriate for a technology driven product that had to address compliance with health and safety regulations and the reliability of new platforms incorporating both hardware and software. Two of the authors formed an exploratory team to determine what were the most important needs of IBA Dosimetry for QFD, which led them to consider both classical and Blitz QFD® as a better fit. This meant that QFD could be adapted to our PCP rather than adapting our PCP to a one-size-fits-all model like the 4-Phase.

We began by interviewing our key product creation process owners representing logistics, human resources, quality assurance and regulatory affairs, sales, R&D, software, procurement, production engineering, strategy, quality, program management, marketing, and product management. This diverse group made clear the improvement opportunities that QFD must deliver:

Product Management/R&D

- Improve understanding of customer applications (use cases) and product concept.
- Improve alignment between customer requirement specifications (CRS) and system/software requirement specifications (SRS).
- Improve documentation of requirements.

Sales/Marketing

- Early involvement, not waiting until release phase.
- Faster product release. Right product at right time.
- Improve customer perceived quality.
- Migrate customers from value to premium priced products.
- Address future market and competitive threats.

- Improve strength of sales and channel management.

Operations

- Reduce design changes, and de-scoping performance and function.
- Improve supplier selection and relationships.
- Clear measurement and monitoring of product and process.

Based on this, a modern QFD process was tailored to include a deep up-front integration with the Discovery process at the R0 and R1 checks, as indicated in this QFD flow chart in Figure *4*. Each of the steps will be explained in detail.

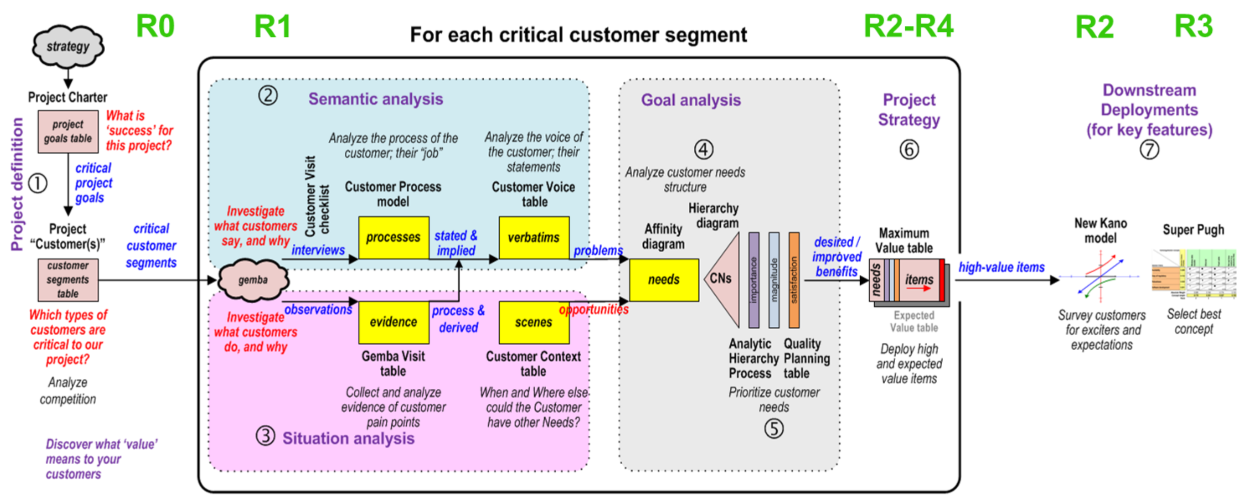


Figure 4 Custom tailored QFD flow chart

R0. QFD in the Product Creation Process: *Discovery*

The front-end process is used to accumulate, and organize product ideas, and then to begin the screening process, as illustrated in Figure *5*. The QFD process gives a powerful tool set to begin this discovery process.

The Discovery stage is a structured mechanism helping IBA to

1. Capture ideas (from all available sources)

2. Cultivate and evaluate them
3. Move the promising ones (Gate 0 decision) forward to the subsequent stage (scoping)

By preselecting ideas, it helps assure that less promising ones are adjusted early for cost optimization.

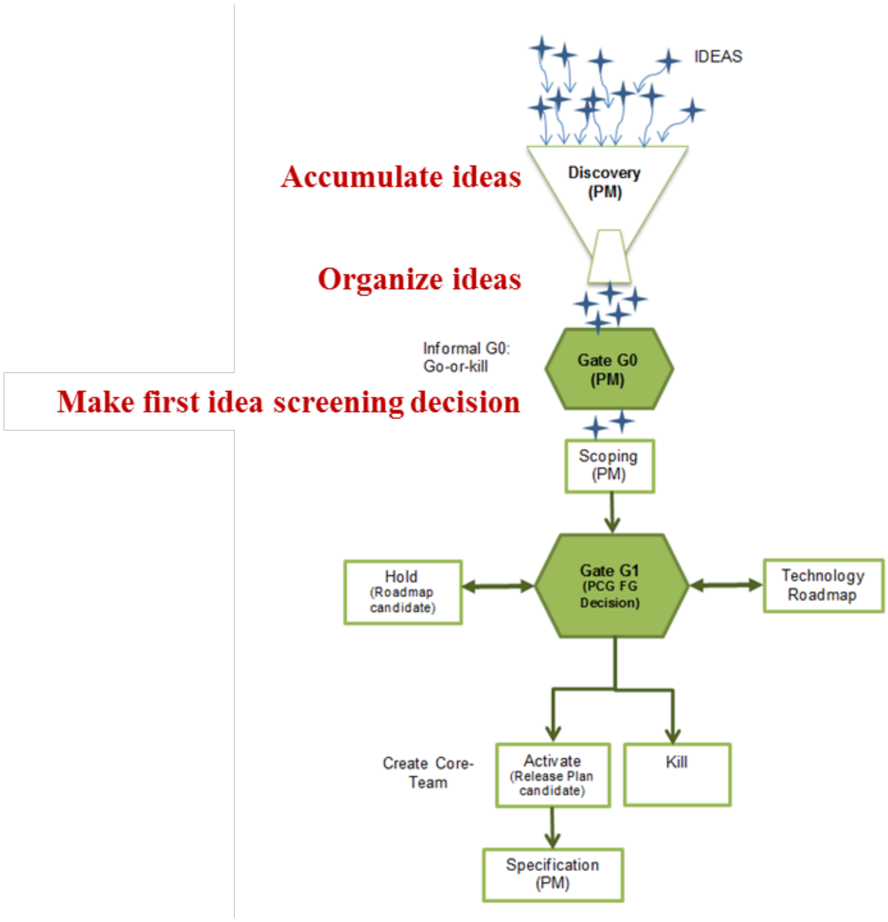


Figure 5 Front end innovation process

Ideas are generated within strategic areas related to market potential, competitive space, technological advancements, and fit to the overall guiding principle of IBA Dosimetry – *We Protect, Enhance, and Save Lives*. The strategy formulation tools in modern QFD (① Project Definition in Figure *4*) include a strengths, weaknesses, opportunities, and threats (SWOT) (Learned et al 1969) analysis to focus us on a subset of possibilities for near-term product projects. Table *1* shows our SWOT analysis with concerns relating to market definition, market size, market growth estimates, major market risks, preliminary assessment of existing competitive solutions, differentiation. These help fashion strategic business goals for the product portfolio.

Table 1 SWOT analysis

Strengths	Key?	Weaknesses	Key?
High competence in R&D	☐	Aimed segment: Low relative market	☐
High customer benefit	☐	Publicity: Not well known with the target	☐
Global market presence/sales quality	☐		☐
Excellent price/performance	☐		☐
	☐		☐
Opportunities	**Key?**	**Threats**	**Key?**
High expenditures are attributable	☐	Barriers to entry are low	☐
New services (own Dos-Lab …)	☐	Rivalry is strong	☐
High market growth rate	☐	Price oriented business	☐
	☐		☐
	☐		☐

Decision criteria help analyze whether the idea fits with the business strategy and our core competencies and acts as a screening filter. Specifically,

- The idea must support a balanced project portfolio.
- The priority is high enough to justify resource assignment to next stage.

These decision criteria are extracted from strategic business goals and help define and measure fit to the business strategy. This is done in a business goals table, as show in

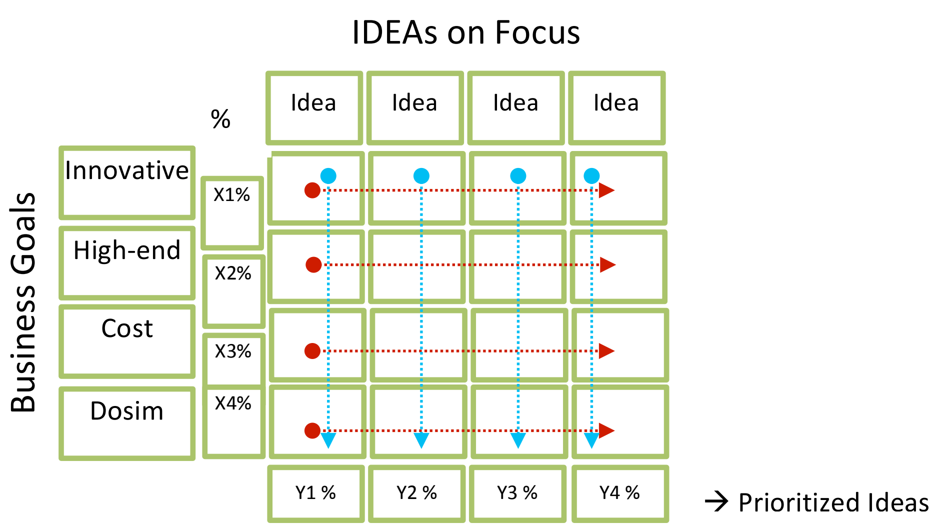
Table *2*.

Table 2 Business goals table

Goal Statement	How meas-ured?	Current level	Target level	By when?	Who judges success?
Develop innovative, high-end solutions.	**# projects**	***x*/year**	***y*/year**	**2020**	**Product Manager**
Reduce equipment costs so hospitals will increase dosimetrists.	**Decrease delivered price**	**€ *aaa***	**€ *bbb***	**2018**	

Prioritizing project ideas can be done using the analytic hierarchy process (AHP) to synthesize and prioritize the ideas using the business goals as judgment criteria, as shown in Table 3. AHP was developed (Saaty 1990, LePrevost and Mazur 2005) to assist is prioritizing a set of alternatives (here, project ideas) by evaluating them against a set of weighted criteria (here, the project goals of innovative, high-end, reduce costs, and increase dosimetrists) from the business goals table above. AHP is especially useful when the using subjective information that is difficult to quantify, in that it uses pairwise voting to create a decision matrix, of which the principle eigenvector closely approximates human judgment. AHP can be used in other decisions in the QFD process.

Table 3 AHP to prioritize ideas



R0. QFD in the Product Creation Process: ***Scoping***

Based on these priorities, Gate 1 decisions are made to activate or kill the prioritized project ideas. For a decision "activate" or "kill", the following questions are asked. If the idea survives, the answers frame the scope of the project and become deliverables or goals of the project.

a. What are the business objectives or success criteria of this project?
b. How is the goal measured?
c. Where does data come from?
d. What is the current level of performance of the goal statement?
e. How well are we doing now?
f. What is the desired level of performance of the goal statement?
g. How well would we like to be doing?
h. What is the target date to reach the target level?
i. Who or what position will determine if the target level has been reached by the target date?
j. Do they have additional metrics?

If these answers are not understood thoroughly by project team members, disagreements can cause confusion later in development process. The project goals table shown in Table *4* is used to summarize these answers, and add a quality twist to asks how these goals will be measured, where they are today and need to go and by when, and who will judge whether they have actually been met.

Table 4 Project goals table

#	Goal Statement	How measured?	Current level	Target level	By when?	Who judges success?
PG1	Create market share in OOO product line	Our units versus total systems sold	*x*%	*y*%	1 year after release	PM / Top Management
PG2	Increase market share in OOO product line	Our units versus total systems sold	*y*%	z%	5 years after release	PM / Top Management
PG3	Increase revenue and profit	selling price - cost = profit	*aa*€	>*bb*€	2 years after release	Sales
PG4	Expand to full solution provider	Market needs versus our product portfolio available	*mm*%	*nn*%	Releas e Date	PM / Top Management

PCP Stage I *Specifications*: The main activity at Stage I Specification is to define what product will be developed. Stage I includes setting up the project structure and planning. Often, this begins with defining the customer applications and who has influence over its purchase and use.

The customer value chain table in Table *5* helps identify which entities we must satisfy for the product to be purchased, used, maintained, etc. To define the value chain of customers from IBA Dosimetry to the end user, we determine

- What do they influence?
- How can they help us?
- How can they hinder us?
- What should we offer?

Table 5 Customer value chain table

Customer	What do they influence?	How can they help us?	How can they hinder us?	What should we offer?
Radiation oncologist	RT team, equipment	include dosimetrist		
Medical physicist	Calibration equipment, treatment planning	recommend vendors	not consulted	promote their role as indispensable, help them delegate tasks to dosimetrists
Dosimetrist			not like our equipment or software	assist in certifcation

Within the value chain, the more detailed customer segments table helps define key customers and their applications and use cases or scenarios. Based on their interactions with the project we learn who are our key customers and how to plan to visit them. The table should be customized for each project but will typically describe these kinds of customer attributes. Additional columns includes financial and market metrics as well as competitive preferences may be added. Table *6* is a partial example of a customer segments table for this project. The solid and broken lines indicate customer applications of high interest to the team.

Table 6 Customer segments table

Project Goals	Goal Wts (from AHP)	Customer Segment	Who can we satisfy?	Clinic zize	Therapy	What are they trying to do?	Where do they do this?	Regulatory	When do they do this?
Increase to zz% market share in OOO product line	28.1%	New RT centers with xxx capabilities	Oncologist	Big Clinic	Cyber-Knife	Daily QA	Americas	TG-101	During the treatment
		Existing RT centers	Physicist	Small Clinic	Gamma-Knife	Machine QA	APAC	IEC XXX	Before treatment
			Distributor	University Clinic	xx MLC Linac	Commissioning	EMEA	TG-53	After treatment
			Dosimetrist	Private xxx center		Plan verification	ROW	FDA	

With limited time, people, and money to conduct customer visits to gather their needs, IBA must be surgical in selecting them. Unlike technical and sales visits that are focused on product issues, the purpose is to understand what problems and opportunities the customers face in their work.

This is called in Japanese a *gemba* visit, a word also used by police to mean a crime scene where evidence is collected. QFD research (Pouliot 1991) has shown that as few as ten visits can reveal substantial, though often incomplete information about customer processes and barriers they face to greater efficiency and quality. Selecting key customers can be done using the alternatives selection mode of AHP with project goals helping to synthesize customer segment priorities, or with a QFD matrix as shown in Table 7. The icons in the center of the matrix are used to indicate the strength of relationship of each customer segment to the weighted project goals. There are nine levels of strengths that have been weighted using AHP that have values from solid circle to open circle of 1.000, 0.759, 0.518, 0.392, 0.267, 0.201, 0.135, 0.102, 0.069 respectively. The project goal weights are then multiplied by the relationship weight and summed for each column. US Onologist is small clinic using Cyberknife is identifies as a top gemba to visit with 44% weight.

Table 7 Project goals - customer segments matrix

Customer Segments / Project Goals	Global Priority from Hierarchy	US university clinic physicist with XXX using Cyberknife for plan verification	US university clinic physicist using XXX MLC Linac for machine QA	US Oncologist in small clinic using Cyberknife for Daily QA	Dosimetrist in private US XXX center using CyberKnife for plan verification
Create *yy*% market share in OOO product line	5.6%	◑ 0.015	● 0.056	◕ 0.029	· 0.000
Increase to *zz*% market share in OOO product line	23.4%	◑ 0.063	◕ 0.121	◔ 0.032	· 0.000
Increase revenue and profit to >*bb*€ in 2 years	11.4%	◕ 0.059	◕ 0.059	● 0.114	· 0.000
Expand to full service provider by release date	42.9%	◑ 0.115	◕ 0.222	● 0.429	◔ 0.058
Absolute Weight		0.251	0.458	0.604	0.058
Customer Segment weight		**18.3%**	**33.4%**	**44.0%**	**4.2%**

The aim of PCP Stage 1 is to provide a market requirement specification (MRS) as the basis for the development of a product and a detailed understanding of the product's use cases, environments and functionalities. It will focus on what the customer needs for the product are but not how these requirements are to be realized. The MRS should identify the problems to solve but not propose a solution. The first step in writing the MRS is to understand why the customer needs a solution, i.e. the problems they face in doing their work in planning and treating patients. If our new product is to be accepted, it must have a large impact on an important customer concern. Otherwise, the cost and effort to replace existing equipment and train operators will not be justified.

R1. QFD in the Product Creation Process: *Specifying*

The modern Blitz QFD® steps shown in Figure 4 support the creation of the Market Requirement Specification (MRS). The purpose of Blitz QFD® is to promote a product development cycle focused on continuous improvement of the customer experience, as shown in Figure *2*.

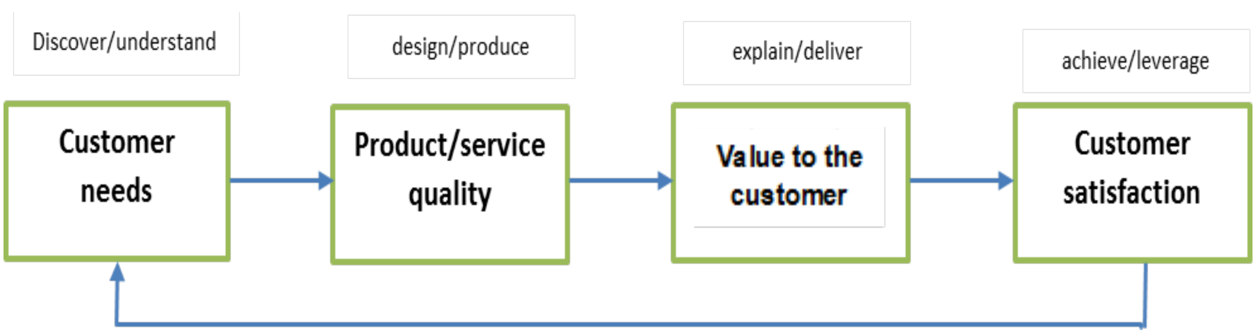


Figure 6 Continuous improvement in customer experience using Blitz QFD®

Semantic Analysis

The Blitz QFD® process begins with a semantic analysis (② in Figure *4*) of the voice of the customer. This is a structured analysis with the customer to better understand the workflow. It is then annotated by the customer to include what goes right in their work (so we don't take away something good), what goes wrong (so we can improve it), how the customer measures their satisfaction or dissatisfaction with that work step or task, and which is their biggest pain point for which we will conduct additional observational analysis. An example of this is the annotated customer process model is shown in Table *8*.

Table 8 Customer process model with annotations

	1	2	3	4	5	6	7
	Regular daily working routine (Patient treatment, document review)	**Setup XXX QA device + start SW**	**Select energy and parameters**	**Beam on measurements**	**Analysis of measurements**	**Repeat the last 4 steps for different settings**	**End of day**
Things gone right		simple usage of SW for setup					
Things gone wrong		cumbersome time consuming setup, device + MC setup not easy for everybody in department (weight constraints)	Tests defined by user can be not sufficient, Setup at the beginning very time consuming. Knowing how transfer to colleagues is preoblematic	Spending lot of time on the machine --> long working day (after Patient treatment)	- Lack of efficiency as more information is available then can be analyzed manually. - Displayed information too much --> confusion of user	Efforts to spend here. More automation favorable	Open end
How is (dis)satisfaction measured? Targets?		Checks need to be finished by 7 am or switch to the end of the day (SW alignment tool) Work-life-balance - More QA in the same time span	Pre-defined tests for quick setup Sharing possibilities of results and test setups	User has to stay long at work. Measurement in hours after end of regular patient treatment (without new product and with new product). Goal: reduce time user has to stay to <50% (<15h) of time used now (30h)	Automatic routines when data available. Target accuracy of 0.1 mm	5 min + beam time, reduction of monthly time (30h) by 15h target	Interruption possibility required, reproducibility of setup is essential (SW correction functionality)
Which tasks are key pain points for the customer?	□	■	□	■	□	□	□

One of the skills required to do QFD well is to translate the voice of the customer (things gone right/wrong narratives) into true customer needs, which are independent of the product features. These narratives explain why many customer issues, including needs, requirements, improvement suggestions, complaints, etc. are important (Mizuno and Akao 1994, p. 337). Then, later in the development and implementation phase, we can be better define and design features based on our emerging technologies. The customer voice table is used to translate customer narratives into customer needs. This table can be customized according to the customer and project. When the narrative is a functional requirement or product feature, we translate back into product-independent customer needs. The value of this is three-fold.

1. Customers are more knowledgeable about their needs than about product features so they can give more accurate priorities.

2. Customers may voice features and may improperly assume that a requested feature will address a specific need.
3. Since needs are product-independent, they foster the innovation process by defining desired outcomes rather than a specific technology to implement them.

Table *9* is an example of translating customer voiced product requirements back into customer needs.

Table 9 Customer voice table (excerpt)

task	clarified items, customer problems	needs		functional requirements
Transportation	easy to handle by handicaped people	Usable by every staff member. Easy to position accurately.		- Design of device needs to offer transportation supports - Lightweight - compact design
Setup	Time saving setup	Increase accuracy of analysis. Increase safety of users. Free up time to be able to repeat tests in terms of improving test quality.		-Design of device needs to be intuitiv for setup --> indication of orientation on device vs. gantry -Alignment via light field and laser system of linac. SW alignment correction tool
Setup	cumbersome (time consuming) setup, device + MC setup not easy for everybody in department (weight constraints)	Easy to handle by every staff member. Easy to position accurately. Quick to position.		- Easy to move for alignment - support of laser alignment with markers - support of light field alignement with markers
Measurements Analysis	Checks need to be finished by 7 am or	Easy to handle by every staff member.		-Calendar functionality -Automized analysis for pre-

Situation Analysis

When customers point out big pain points in their work steps or tasks, more detail can be learned by observational studies in the *gemba* (③ in Figure 4). Here the QFD team can employ all their senses (sight, sound, touch, taste, smell) as well as their critical thinking to assess this important improvement opportunity. These sensory inputs are then clarified and identified as either benefits (need) or features (functional requirement), which can then be added to the appropriate columns in the customer voice table. Table *10* is an example of this *gemba* visit table.

Table 10 Gemba visit table

Process Step, Tasks	Observations	Verbatims	Documents, Data	Team Notes	Clarified Items *with measures*	Benefit or Feature?
Deliver & measure representative XXX fields	Task was executed by the Dosimetrist. All needed measurements are acquired in one shoot.	The dosimetrist highlighted the good usability and its simplicity.	See screen shoots from SW	As mentioned in T1 the main failures are connected with the wrong gantry position and only detected relatively late (ending up in "Morning Calls" to him which he does not like). He also was mentioning that a better resolution would be of help.	Task can be performed with dosimetrist skills.	B
					Measurements acquired in one shoot.	B
					Additional parameters like gantry angle should be logged to help increase the workflow	F
					Additional parameters like collimator rotation should be logged in addition and would help to increase the workflow efficiency.	F
					See screen shots from SW.	F
					Can tell if gantry position is correct at the	F
					Tests do not need repeating.	B
					Need better resolution.	F

Customer Goal Analysis

When writing the Market Requirements Specifications, we want to pay special attention to where the customer has a critical need and where there is a competitive threat or opportunity. We also want to ascertain if there are minimum acceptance levels for the customer to be satisfied or maximum levels beyond which improvements are not helpful.

To determine which customers needs are most critical to the customer, the analytic hierarchy process (AHP) has become a standard QFD tool. AHP holds these advantages over the 1-5 rating scales seen in classical QFD from the 1970s (Saaty 1990).

- It yields more accurate ratio scale priorities that support later QFD math functions. The 1-5 scale in ordinal and should not be used in math functions such as +, -, x, /." This is because the ordinal scale does not have fixed intervals between the levels (Stevens 1946).
- Human stimuli and response to "noticeable differences" is quite good when comparing two items at a time (Miller 1956).

- Prioritization along a hierarchy is less tiring than with a list.

AHP can be done in a spreadsheet as shown in Table *11*. IBA Dosimetry recently licensed an AHP software program that has been adapted for customer needs prioritization, called SelectPro (www.selectprosoftware.com/purchaseQFD.html) Customers are asked to compare needs, two at a time, selecting which is more important, and by how much. They are asked to respond on a verbal scale using the words extremely, very strongly, strongly, moderately, or equally important, and a corresponding value of 9 to 1 are entered into the decision matrix, as shown here. As explained earlier, the principle eigenvector of the matrix is calculated to approximate the relative importance of the needs (shown as row avg in the table). As these values are in absolute relative scale with ratio scale properties, there is no mathematical problem adding or multiplying them in later QFD steps.

Table 11 Prioritizing customer needs with AHP

Easy start of day	Quick to set up in am	Reproducible setup	Setup is operator independent	Minimize walking between workstations					sum	row avg
Quick to set up in am	1	3	5	7	0.597	0.662	0.536	0.438	2.232	**0.558**
Reproducible setup	1/3	1	3	5	0.199	0.221	0.321	0.313	1.053	**0.263**
Setup is operator independent	1/5	1/3	1	3	0.119	0.074	0.107	0.188	0.487	**0.122**
Minimize walking between workstations	1/7	1/5	1/3	1	0.085	0.044	0.036	0.063	0.228	**0.057**
	1.676	4.533	9.333	16.000	1.000	1.000	1.000	1.000	4.000	1.000
									Inconsistency Ratio	0.04

Competitive preferences as well as satisfaction levels can be recorded in the quality planning table shown in Table *12*. Measurements can represent actual performance information such as time, required training, etc. or even just an ordinal rating. This table can augment competitive a value curve analysis by focusing on high priority needs first. In cases where a Kano Model (Kano et al 1984) survey is planned, the table can be used to predict which needs should drive the survey. Kano survey results will be used in the downstream deployments in ⑦ in Figure *4* to help define what performance levels and functions are basic expectations or will excite the customer.

Table 12 Quality planning table

Key Customer Needs	information: Importance – From Renormalized CN Hierarchy diagram	Current situation – Magnitude of current performance level	Current situation – Satisfaction with current peformance level	Hoped for situation – Magnitude of hoped for performance level	Hoped for situation – Satisfaction with hoped for peformance level	Competitiveness – Competitive Choice	Competitiveness – Selling Point Potential if hoped for level met	Kano – Prediction of Kano Catergory
Meaningful results	49.1%	4	Satisfied	5	Very satisfied	4	minor	Desired
No repetition if linac is correct	29.1%	3	Neutral	4	Satisfied	3	none	Exciting
Immediate results	15.1%	2	Dissatisfied	4	Very satisfied	3	major	Desired
Easy to share results	6.7%	3	Dissatisfied	3	Neutral	3	none	Expected

R1. PCP Stage-II: *Design*

The main activity of the Stage II Design is to define how a product will be developed. Therefore, the market requirements are transferred into technical development requirements by identifying high priority functional requirements for high priority customer needs. IBA analyzes a number of issues related to usability, risk, as safety as well. This process is shown in Figure 7.

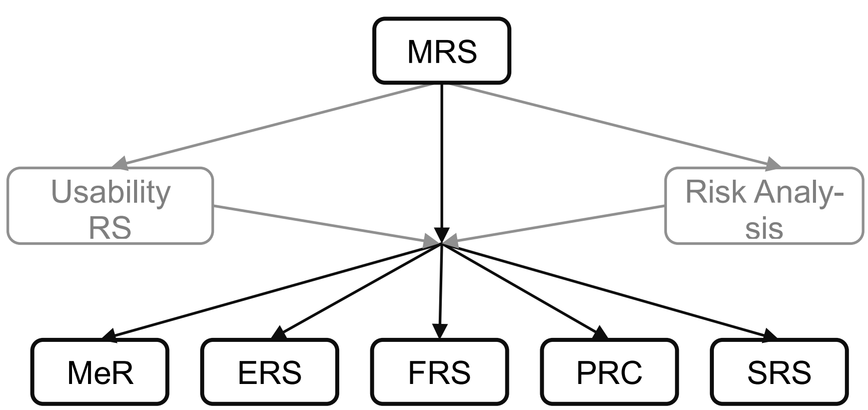


Figure 7 IBA product requirement analyses

Project Strategy

Detailed design activities related to the high priority customer needs can be launch right away using the maximum value table shown in Table 13. This table works best when limited to a few needs, and can be used to track the entire development, build, and support activities to assure quality.

Downstream Deployments

Very new or very complex products may require analysis of more than the top few customer needs. In such cases, the classical QFD tool, house of quality matrix (HoQ) may be used with the maximum value table. Unlike the maximum value table which examines the many design dimensions related to each customer needs, the HoQ only looks at the relationships between customer needs and functional requirements as shown in Figure 8. Other design dimensions will have their own matrices; this could be as many as 30 additional matrices! So do the maximum value table first.

Table 13 Maximum value table (excerpt)

Customer				Product Requirements Analysis							
CRS				Functional Requirements (CRS)			Solution Specifications (SRS)				
segment	tasks	problems/ narratives/ clarified items	needs	characteristics & capabilities	performance target, accuracy	applicable standards and QA plan	functions (hardware)	processes (service)	objects (software)	Kano category	risks, system failure modes
XXX users	Machine QA	Resolution could be improved with more parameters	Meaningful results	Measure parameter accoding to standards	Energy, Flatness, area symmetry according to AAPM TG 101	AAPM TG 101	2 mm detector pitch			Expected	Mistreatment, delay treatment

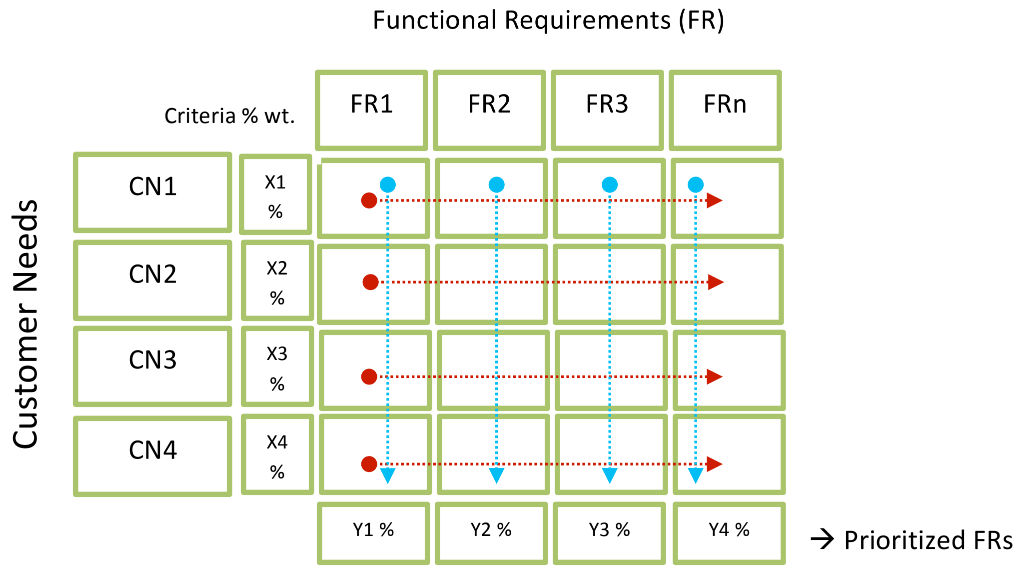


Figure 8 House of Quality concept

As the next step, the core team evaluates various technology alternatives to select the best possible concept (BPC). The prioritized functional requirements from the HoQ can be used as selection criteria, using a Super Pugh process which combines the concept hybridization and selection process of Stuart Pugh (Pugh 1981) and the prioritization power of AHP. Once the BPC are selected, their requirements can be deployed to detailed functional requirements (DFR) that are now specific to their technology, as shown in Figure *9*.

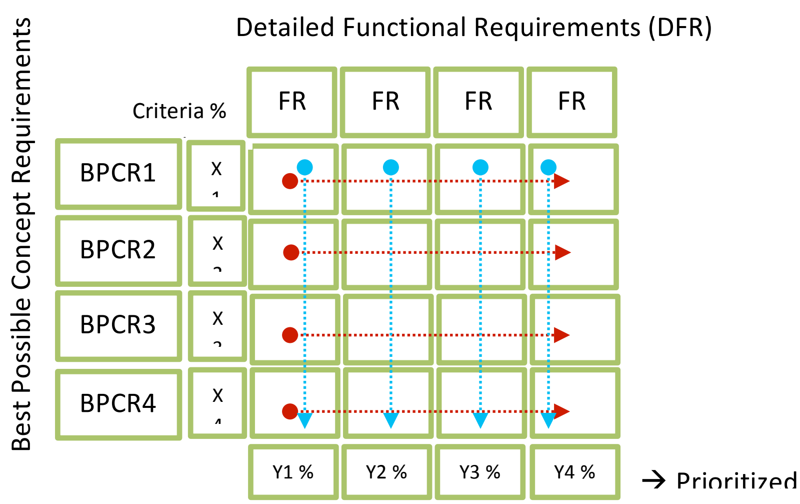


Figure 9 Concept – detailed functional requirements matrix

Conclusions

With the introduction of the QFD methodology at IBA Dosimetry, we are committed to the following:

- → The customer expectations to our new products shall be met for certain.
- → It shall help us to make a clear technical specification from verbal customer wishes.
- → We will concentrate on essential points to shorten development time.
- → We will avoid undesirable developments and not pass them into the market.
- → We will improve product and competition analysis correctly.
- → We will reduce product costs and investments to the lowest level necessary.
- → We will see improved teamwork within the company as projects are processed by different departments working together.
- → Detailed product knowledge built up by all departments involved at the end of a project will be reutilized for future projects.

Our initial findings have shown that:

- The QFD method gains acceptance only slowly in the company. Discussions are necessary to dismantle resistances, and team members show great enthusiasm once they have been on a QFD team.
- Department-oriented silo thinking can inhibit this required team spirit.
- We cannot always rely on ideal team composition and discipline. We must work at it.

Success will come because:

- Support by the executive management team is very high.
- Intra-company problems are uncovered by QFD application.

First projects require more time because there is both learning the QFD method and developing the project. The learning effect and the use of the data from previous projects should however reduce the high time expenditure quite considerably with regular application of the QFD method.

IBA Dosimetry Schwarzenbruck QFD training

Since 2013, IBA now has 32 people (16%) certified QFD Green Belts®. Six of those have undergone QFD Black Belt® training, and will train future QFD Green Belts®. Our goal is to have them train and certify all employees in the company as QFD Green Belts® and then carry the method to other business groups within IBA.

The QFD Green Belt® programs were three days in duration, and included guest visits from physicists at two local hospitals, who presented on their facilities and diagnostic/treatment processes. Later, visits to real *gembas* to talk and observer customers were included in the actual projects. The QFD Black Belt® program consisted of eight class days divided into two sessions with customer visits in between the sessions. At the conclusion of the second session, new projects were assigned to teams of QFD Green Belts® to be led by the newly minted QFD Black Belts®. Projects will be reviewed regularly by the management team, and the process continuously fine-tuned.

About the authors

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Glenn H. Mazur has been active in QFD since its inception in North America, and has worked continuously with the founders of QFD on their teaching and consulting visits from Japan. He is a leader in the application of QFD to service industries and consumer products, conducts advanced QFD research, and is the Conference Chair for the annual 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, President of Japan Business Consultants Ltd., 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. He received the Akao Prize® for excellence in QFD in 1998. He is convenor of the ISO Working Group 2 of the Technical Committee 69, Subcommittee 8 to write the international standard for QFD (ISO 16355) and a member of the Technical Committee 176 responsible for ISO 9000 series standards. He is an Academician and Secretary-Treasurer of the International Academy for Quality.

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