

Breaking the Customer Code

A model to Translate Customer Expectations into
Specification Limits

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Linköping, Sweden 2008

THESIS FOR THE DEGREE OF MASTER OF SCIENCE

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ABSTRACT

Today, firms compete with services rather than goods. Large service organizations are beginning to use Six Sigma as continuous improvement tool. An important part of the Six Sigma methodology is the calculation of number of defects in the process, i.e. points outside the specification limits.

Unlike goods quality, which can be measured objectively by number of defects, in service goods the setting up of specification limits is a complicated issue because it is marked by the use and expectations among the different customers. As Six Sigma was originally created for manufacturing, this crucial fact is not contemplated in the Six-Sigma roadmap Define- Measure-Analyze-Improve-Control (DMAIC).

The aim of this thesis is to develop a new model to help the Service Division, Siemens Industrial Turbomachinery AB to set the specification limits according to the customer expectations.

A review of relevant literature is used to develop a new integrated model with ideas from the Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, the "Trade-Off Importance".

A survey was carried out for 18 external customers and internal stakeholders.

The model has demonstrated its robustness and credibility to set the specification limits. Additionally it is a very powerful tool to set the strategic directions and for service quality measurement.

As far as we know, this thesis is the first attempt to create a roadmap to set the specification limits in services. Researchers should find a proposed model to fill the research gap. From a managerial standpoint, the practical benefits in Siemens Industrial Turbomachinery AB, suggest a new way of communicating to customers.

Keywords Customer satisfaction, Service industries, Six Sigma, Specification Limits, Kano model

“Twenty years from now you will be more disappointed by the things you didn’t than by the ones you did do. So throw off the bowline, sail away from the safe harbor. Explore, dream, discover”

Mark Twain, (1880)

Acknowledgements

This thesis has been conducted at the Service Division of Siemens Industrial Turbomachinery AB in collaboration with the Division of Quality Technology and Management at Linköping Institute of Technology.

There are many people I would like to thank for helping me through this work. First of all I would like to thank my Industrial Supervisor, Dr. Peter Cronemyr. He is a great person. You have taught me what research is all about. Peter has proven that it is possible to play the role of both a serious supervisor and a friend. Thank you, Boss!

I am also thankful to the Black Belts and the managers at the Service Division for the valuable help and support. All the members of the Business Excellence department in the Service Division for the nice "fikas" (coffee breaks) together, specially to Hedley Cunliffe. And of course to Clement and Fabien for the good lunches and time together.

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To my best friends: Arnau, Gerard, Borja, Juanca, Paco, Hugo, Roger and Virgili, you are very important for me. Also to my friends in Sweden, Christian, Leonardo, Loïc, Jenny, and Solange; I know that even if we are from five different countries we will keep this friendship.

Finally, I give my deepest gratitude to my parents and brother for their never-ending support, interest and attendance in the thesis presentation.

I wish that the readers of this thesis will find their time reading enjoyable and well spent.

Ruben Gregorio
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Finspång, February 2008

About the author



I would like to give a short background on who I am, which in some ways has probably affected the work presented in this thesis. I am twenty-three years old; I grew up in Tarragona, a city by the sea one hundred km from Barcelona. I studied in Barcelona and in Linköping. I lived in Sweden, in an International Campus with more than eight hundred students from thirty countries. There is an economic phrase that says “*go global, think local*”, in this exchange program I had the great opportunity to “*go global*” with students from all over the world. But also to “*think local*” discovering the Swedish culture, society and values. I believe that it is a great experience that I recommend to everyone.

I have been employed in Siemens to write my Masters Thesis for a double engineering diploma program, M.Sc. in Industrial engineering in Barcelona School of Industrial Engineering-Technical University of Catalonia (UPC) and M.Sc. in Manufacturing Management in Linköping Institute of Technology. In 2005 I graduated from a B.Eng in Electronic Engineering by ETSE.

This Thesis marks the end of my student life. I think that a university program is a trip, not a destination. I always believed that it is not just the amount of courses that you have to memorize to pass some exams. It is also the opportunity to live outside, to mix with other students, to be active in the different student activities that enrich yourself as a person. You are what you have lived. This student life, this exchange program and all of these experiences will definitely mark my personality and way of thinking. As I quote in the thesis phrase, in twenty years I will regret more about the things that I didn't do than the things I did. I have it clear, I want to navigate, I want to explore...

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Article A

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INTRODUCTION

During the last 20 years, there has been steady growth not only in the service sector but also in the service content of most products (Nilsson, 2002). Research scholars suggest that firms now compete with services rather than goods (Rust, 1998; Grönroos, 2000; Vargo and Lusch, 2004). Harris and Harrington, (2000) claim that that the opportunity area for the twenty-first century is in the understanding and improvement of the service processes putting the customer in the centre of the issue. Phillips-Donaldson, (2005) in the article “*The Rock Stars of Quality*” states that the next breakthrough –and rock star (referring to the next guru in quality management)- is likely to come from the service sector.

The well-published financial benefits of Six Sigma in manufacturing are beginning to energize large scale application in services (Antony, 2006). Reported case studies of Six Sigma in services are scattered in a wide range of publications e.g. Cronemyr, (2007). Six Sigma is being used in banking, healthcare, accounting and finance, public utilities, shipping and transportation, airline industry, education (Antony, 2006).

An important part of the Six Sigma methodology is the calculation of number of defects in the process, i.e. points outside the specification limits. However Unlike goods quality, which can be measured objectively by number of defects, for example in figure a) the line that separates black and white is clear (figure a). In service processes the setting up of specification limits is a complicated issue because it is marked by the use and expectations among the different customers. The line that separates black and white in the figure b) is diffuse, different persons would answer different places to set the line. As Six Sigma was originally created for manufacturing, this crucial fact is not contemplated in the Six-Sigma roadmap Define- Measure-Analyze-Improve-Control (DMAIC).

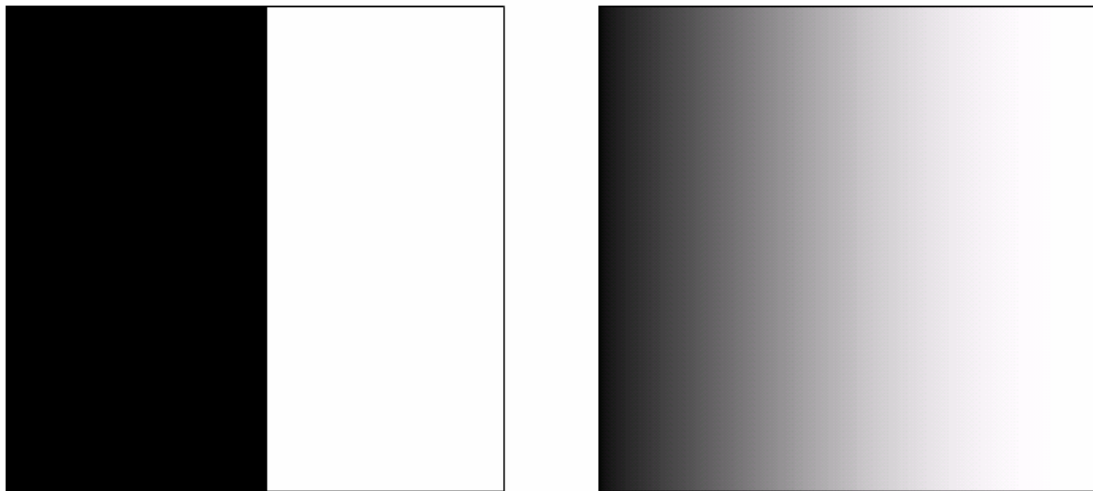


Figure 1 a), Figure 1 b)

Walter A. Shewhart viewed quality from two related perspectives: the objective and subjective side of quality (Shewhart, 1931). The first perspective views quality as an objective reality independent of the existence of man. In contrast, the subjective side of quality considers what we think, feel and sense as result of the objective quality.

Despite differences in expression, the two aspects of subjectivity and objectivity have revolved around since the time of Aristotle, (350BC) (Kano et al., 1984), and some popular models are

widely used both by academics and practitioners, to link these two sides e.g. the Kano model, Quality Function Deployment, Puga-Leal and Pereira, (2007) model, classification through direct questions, Importance Performance Analysis, Kansei engineering, conjoint experiments. However, none of these approaches serve to successfully transform the voice of the customer into specification limits in services.

This Thesis aims to resolve this issue developing a roadmap to systematically set the specification limits in services linking the subjective side of quality with the objective side. To do so, one integrated model is presented, combining ideas from the Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, the Trade-Off importance.

Six sigma

“Increasing competitive pressure in all business sectors is reflected in the continuing quest for business improvement philosophies and methodologies to address this challenge.”

McAdam and Lafferty, (2004)

This thesis job is done within the Business Excellence department in the Service Division II. There is a strong Six Sigma program. Six Sigma was introduced by Motorola in the 1980s and made famous by General Electric in the 1990s. Since then it has spread widely and is now, some ten years later, used by many famous companies around the world (Cronemyr, 2007).

Six sigma is in essence a structured way of solving problems in an existing process based on analysis of real process data i.e. facts. One could argue that the tools are nothing new, but rather a set of long well-known tools used within quality management, but on the other hand without Six-Sigma these tools would probably still be the possession of a limited number of people. What makes the Six-Sigma roadmap (MAIC) something new is rather the structuring of the individual tools to the process itself, which is basically the Shewhart cycle. See, e.g. Bergman, et al., (2002) (Cronemyr, 2007).

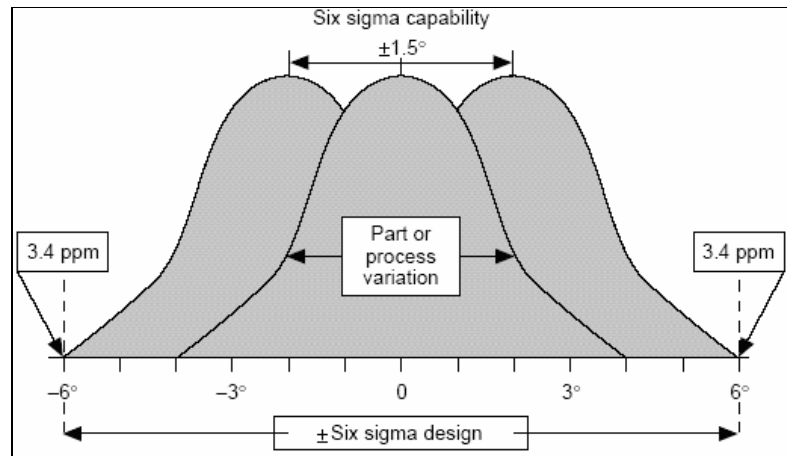


Figure 2- Six-sigma process. Six sigma signifies “best in class”, with only 3,4 defects per million operations, and it stresses that all errors are predictable. Adapted from Behara et al., (1995).

The Six Sigma program in Finspång was started by Alstom Power. Even though the ABB Corporation is famous for being one of the first companies to use Six Sigma (Magnusson et.al., 2003), it was not used by ABB STAL in Finspång until Alstom Power introduced it in 2001. Later, a Siemens top manager expressed his view of what had been achieved by the Six Sigma program at Alstom Power as ‘embarrassing’. But, as Juran once said, “*Failure is a goldmine*” (Juran, 1998). (Cronemyr, 2007) The feeling in that moment was that it was an absolute failure, not a goldmine, but avoiding the same mistakes again was an important factor for the successful implementation of the six-sigma program in the service division.

The company

Siemens Industrial Turbomachinery AB (SIT AB) in Finspång Sweden is a part of Siemens AG, a world leader in power supply, transmission and distribution. The company in Finspång has an approximately century old history of making turbines. Several name signs have been put up and taken down from the roof of the main office: Svenska Turbinaktiebolaget Ljungström (STAL), STAL Laval, ASEA STAL, ABB STAL, Alstom Power and, since 2003, Siemens. The company delivers gas turbines, steam turbines, turn-key power plants, and service and components for heat and power production. The facility in Finspång employs some 2 200 people with an annual turnover of 650 Million Euros. Siemens AG employs 475 000 people in 190 countries worldwide, with an annual turnover of 87 Billion Euros in 2006 (Cronemyr, 2007). The company is not just selling a high quality turbine, the company is selling a “shared future” with the customer. With nearly 700 employees the service division plays a crucial role for the competitiveness of the company.

Background

Cronemyr, (2007) developed a model for process management that is being used by the Service Division in SIT AB. According to this approach (see figure) the first step is mapping processes

(middle), second run Six Sigma projects (bottom) and third go for the process control (top). Phase 1 and 2 are running successfully. A thesis work was developed to define whether the workers agree with the process development approach, which showed that a majority of the employees thought that the process orientated development at the Service Division was the right thing to do.

Currently the Phase 3 is not used in the right way. The control phase is performed with a bar chart with the monthly average value. The decisions are made according to the difference of this value and one target value without taking into account the process variation and sometimes setting the target values by guessing. In an other Master Thesis project, process control charts were developed. This Master thesis has closed the Process Control loop by setting the target values based on the real customer needs and will allow the company to use a SPC control loop in its full potential.

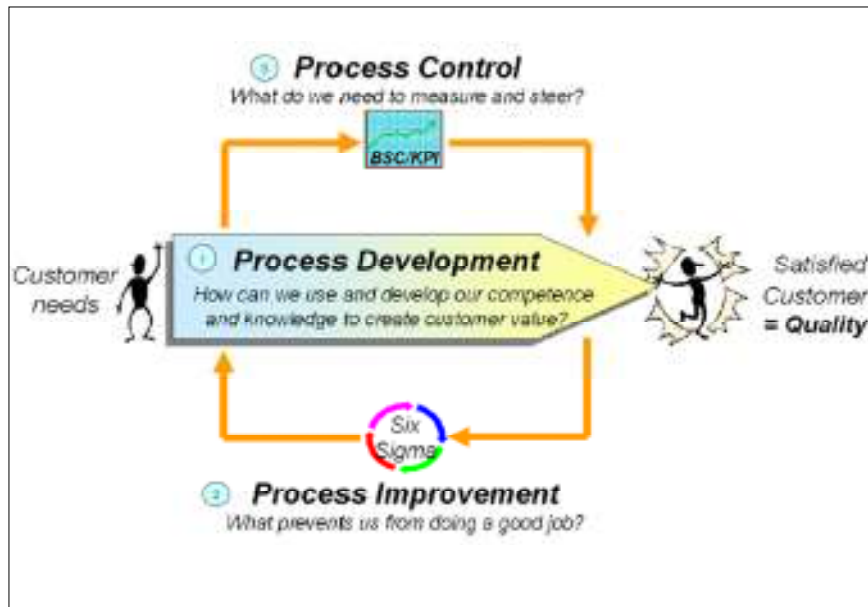


Figure 3- Process Management at Siemens Source: (Cronemyr, 2007)

Research questions of the thesis

The general research question of the thesis is:

How to transform customer expectations into specification limits

The sub-questions of the specific sections are all connected to this overall question. These are:

- Is there any model in the literature to answer the general question? From the models in literature which are the most suitable? (Section I)
- Which are the problems of the models selected from the literature working separated? (Section II)
- How the model is constructed (Section III)
- Which is the company problematic? Which are the results of the model? (Section IV)
- Conclusions and discussions (Section V)

Thesis outline- A Reader's Guide

The thesis is organized in five different sections, each of them with an abstract, introduction and conclusion. These sections are organized as independently as possible to help the reader to focus on the part that he or she is interested in.

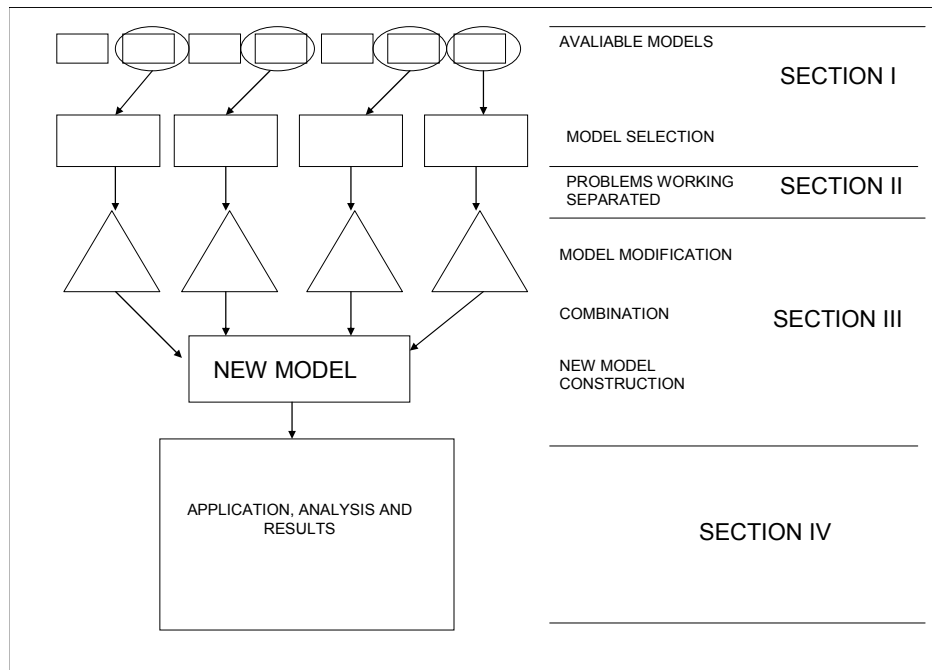


Figure 4- Relations between the Thesis section

Reliability

The role of reliability is to minimize errors and biases in the study (Yin, 1994). To enhance the reliability of the work presented in this thesis we have tried to describe our methodology and strategy in such a way that possible errors, previously undetected, can be detected and further researched by the reader. This thesis was reviewed by Peter Cronemyr and Simon Schütte, both of them with a long industrial experience and also a large experience from research. This company and academic review increase the reliability and validity of the thesis.

We carefully selected a representative sample of eight internal stakeholders and nine external customers, from different functional areas and different countries. We had one hundred per cent of response rate. In the case of a too low response rate, the customers that are dissatisfied and delighted will answer, it does not give the general opinion, this high response rate enhances the reliability of the study.

External Validity

External validity, often referred to as generalisability, see e.g. Blair and Zinkhan, (2006), refers to how generalizable findings are across times, settings and individuals (Scandura and Williams, 2000). The use of a variety of methods might result in higher external validity (Scandura and Williams, 2000). From this point of view, the use of four different models and integrate them for service quality measures, the use of questionnaires, interviews and a literature review may have contributed to a more robust and generalizable set of findings. The generability of the method is

has been strengthened by the fact that the model and the questionnaires has been uses with two different types of customers, internal and external.

The literature review

A literature review was conducted in order to compile and interpret previous work done in the field of study. This review was necessary in order to make certain that the study does not address a trivial problem, has been studied before, and help the researcher to avoid mistakes that other have made (Merriam, 1988). A search of research papers and conceptual papers was made in different databases such as “*Emerald*” and “*Business Source Elite*”. A limitation of this methodology was that only papers in English were considered. It is possible that this restriction excluded worthwhile publications in other languages, especially in Japanese (even though many Japanese papers have been translated into English). Research was also made in books, journals, Black Belt projects, KPI’s, external audits, company business cases, previous master thesis in the company and internal data.

Section I

MODELS FOR SERVICE QUALITY MEASUREMENT- A literature review and model selection

From the beginning of the 1980s, quality awareness and customer consciousness have been growing steadily (Leonard and Sasser, 1982). In a highly competitive marketplace, organizations need to adopt strategies and to create service attributes targeted specifically at exciting customers and over-satisfying them. (Tan and Pawitra, 2001) Despite this, no literature has appeared that brings together the current state of knowledge on service quality measurement. The aim of this section is (i) to synthesize and organize the extant literature on the subject; (ii) to select the most suitable model for each classification (ii) to serve as a guide for further reading and research; and (iii) to serve as a baseline for model construction (section 3).

A search of research papers and conceptual papers was made in different databases such as “Emerald” and “Business Source Elite”. A limitation of this methodology was that only papers in English were considered. It is possible that this restriction excluded worthwhile publications in other languages, especially in Japanese even though many Japanese papers have been translated into English. Research was also made in books and Journals.

INTRODUCTION

“Focusing on process management/process improvement, benchmarking, technology and hundreds of other competitive tools in everyone’s arsenal has little impact on competitive position without a keen understanding of customers and the many changes that occur in their service requirements”

Harris and Harrington, (2000)

Customer focus is essentially a Darwinian situation, the survival of the fittest. One can buy the most precise and expensive bow in the market. If it is not calibrated all this investment will not be reasonable; hitting the target would be a matter of luck. All organization needs to measure the service quality and set the targets according to customer needs. No internal continue improvement philosophy (good bow) make sense if the organization have no clear that the customers have the last word.

Despite of this, firms frequently fail to understand customer requirements, the usual methods for measuring customer satisfaction are incomplete and no research study has provided a global view of the different tools used for service quality measurement.

As far as we know, in the literature there is any roadmap to set the specification limits. The aim of this thesis is to create this new approach. As a baseline for this new model it is important to select the available models in the literature for the specific needs. In this section, the different models are grouped into four categories classification of quality attributes, perceived performance measurement, objective performance measurement models for target setting and attribute importance measurement and one model is selected in every classification.

Service quality and customer satisfaction

“The highest need of every customer is to be understood, listened to and appreciated”

Harris and Harrington, (2000)

According to Deming, (1982) service quality aims to confirm the requirements of customers, to meet their expectations and to satisfy them. In the literature it is generally agreed that service

quality is distinct from customer satisfaction. Although the exact nature of this distinction seems to be somewhat blurred. Some argue that while service quality is an overall attitude towards a service firm, customer satisfaction is specific to an individual service encounter (Bolton and Drew, 1991; Parasuraman et al., 1988). For instance a customer may be very satisfied with an individual service encounter in a bank, but his/her overall attitude towards that bank might be one of offering poor service (Robinson, 1999).

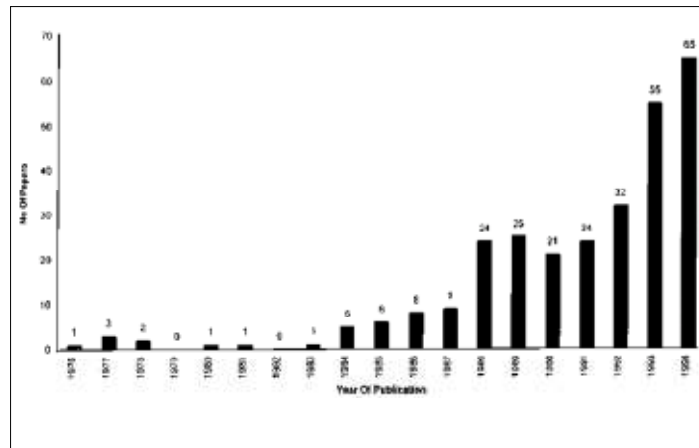


Figure 5- Growth on publications of service quality. There is an exponential increase of attention in this topic Source: Philip and Hazlett, (1996)

CLASSIFICATION OF QUALITY ATTRIBUTES

“It will not suffice to have customers that are merely satisfied. A satisfied customer may switch... It is necessary to innovate, to predict needs to the customer, give him more”.

Deming, (1994)

The battle between video systems VHS and Beta was won by VHS even though it had a lower picture quality. The customers, however, thought that the picture quality of VHS was good enough and choose VHS because it had a much smaller cassette. (Stalhane, 2002) The quality of the picture seems to be more important attribute than the size of the cassette. Why did the customers decide VHS even if the most important attribute had a worse quality? With an attribute classification model an organization can have a better customer understanding and improve the attributes that will make a competitive difference.

Alternative models



Dr. Noriaki Kano is Japanese professor and international consultant. Bicheno, (1998) considered him one of the nine “Gurus” in the Quality Management field. He received the individual Deming Prize in 1997 and he is the President of the Japanese Society for Quality Control. Dr. Kano challenged the traditional ideal on customer satisfaction that “more is better”, that the better you perform on each product or service attribute, the more satisfied the customers will be.

Instead, Dr. Kano held that performance on product and service attributes is not equal in the eyes of the customers. Performance on certain categories of attributes produces higher levels of satisfaction than others (Zultner et al., 2006).

Witell and Löfgren, (2007) made a literature review, and one of their findings was that most of the empirical articles in the review (22 of 29) were published in the present century, which indicates a growing interest in the theory of attractive quality.

Since the presentation of the Kano model in 1984 there have been presented alternative approaches for attribute classification. The most important in the literature according to Witell and Löfgren (2007) are Kano Three-level questionnaire (Kano et al., 2001), Classification through direct questions (Emery and Tian (2002) and classification via importance (Jacobs, 1999).

Witell and Löfgren (2007) made an investigation including the four approaches to compare them in a methodological perspective and from an output perspective. The different approaches are described, analyzed and discussed in the context of an empirical study that investigates how 430 respondents perceive the performance of an e-service. They found out that the classification of quality attributes are dependent of the approach that is utilized.

We made an analysis of the classification through direct questions (Emery and Tian, 2002) and classification via importance (Jacobs, 1999). We found them more difficult to answer and to understand than the classic Kano 5-level methodology. The Kano 3-level reduces the set of answers from five to three. We think that there is a loss of information.

Model selected, Kano 5-level model

Witell and Löfgren (2007), recommend practitioners to use the five-level Kano methodology. This research is the only attempt to compare alternative approaches therefore the Kano five-level model is selected in this category and discussed with more detail.

The model underlying Kano theory has its roots in social psychology and Motivation-Hygiene theory (M-H theory) developed in 1959 by Frederick Herzberg. Herzberg created a theory to explain the way employees feel about they work. Herzberg observes that the set of factors that produce job satisfaction are separate and distinct from the set of factors that produce job dissatisfaction. In effect there are two different axes (Bolster, 2003). The motivator factors, if fulfilled, produce job satisfaction, but if absent they do not provide job dissatisfaction, they provide an absence of job satisfaction.



Figure 6- Herzberg M-H theory is the origin of the Kano model Source: (Pouliot, 1993)

Herzberg thinks of the one axis as the motivator axis. In this dimension the employee seeks personal growth, absence of this growth does not cause pain, one example of this dimension is recognition. The other axis is the hygiene axis. In this dimension the employee tries to avoid pain from the environment; however, the avoidance of this pain does not produce satisfaction, for example security at work (Pouliot, 1993).

Kano theory, originally termed the “*M-H Property of Quality*” was first proposed in a paper published in 1979 and fully developed in 1984 in the paper “*Attractive Quality and Must-be quality*”.

Kano methodology

In his model, Kano (Kano, 1984) distinguishes between three types of product requirements which influence customer satisfaction in different ways when met:

Must-be requirements: If these requirements are not fulfilled, the customer will be extremely dissatisfied. On the other hand, as the customer takes these requirements for granted, their fulfillment will not increase his satisfaction. The must-be requirements are basic criteria of a product. Fulfilling the must-be requirements will

only lead to a state of "not dissatisfied". The customer regards the must-be requirements as prerequisites, he takes them for granted and therefore does not explicitly

One-dimensional requirements: With regard to these requirements, customer satisfaction is proportional to the level of fulfillment - the higher the level of fulfillment, the higher the customer's satisfaction and vice versa. One-dimensional requirements are usually explicitly demanded by the customer.

Attractive requirements: These requirements are the product criteria which have the greatest influence on how satisfied a customer will be with a given product. Attractive requirements are neither explicitly expressed nor expected by the customer. Fulfilling these requirements leads to more than proportional satisfaction. If they are not met, however, there is no feeling of dissatisfaction.

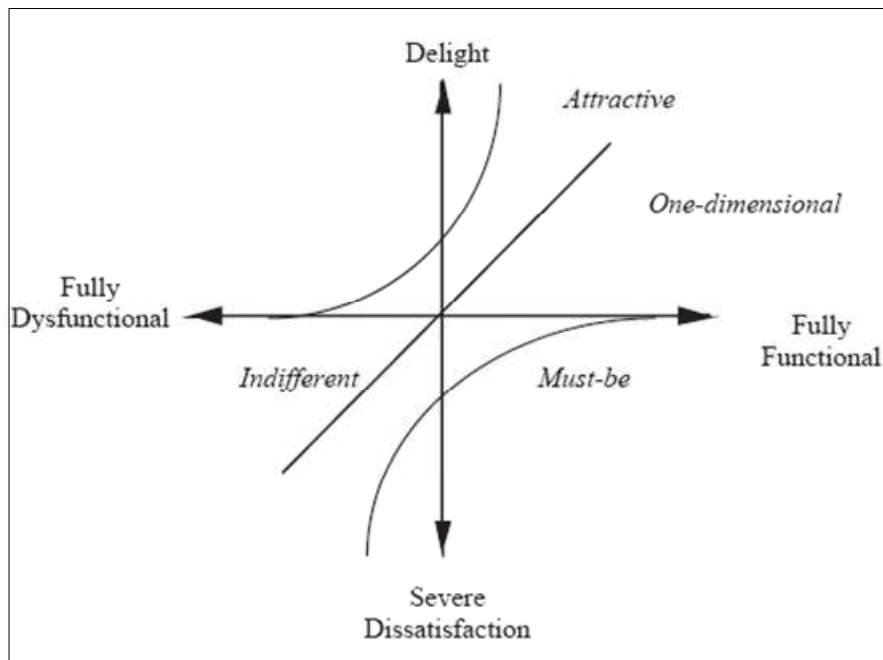


Figure 7- Kano model of customer satisfaction. Source: Pouliot, (1993)

For better understanding I will explain it with one example. Some weekends ago I went with some friends to one pub in Linköping. The bar was clean, we did not notice it because it is a must-be attribute. If the pub was dirty we would have been dissatisfied. The price of the beer is an example of a one-dimensional attribute, the cheaper the better. If the price increases over what you are willing to pay it leads to dissatisfaction. Some friends wanted to go out to smoke. We had our jackets in the wardrobe and it was cold outside, it was October in Sweden. When we were going out we were offered a blanket to cover ourselves while smoking. This is an example of an attractive attribute, we did not expect it but we were very satisfied with the service offered.

The Kano attributes are classified by means of a questionnaire. The customer is asked in the functional and dysfunctional form the same question i.e. how would you feel if the attribute has a good performance (functional) and how would you feel if the attribute has a bad performance (dysfunctional).

If the edges of your skis grip well on hard snow, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
If the edges of your skis do not grip well on hard snow, how do you feel?	6. I like it that way. 7. It must be that way. 8. I am neutral. 9. I can live with it that way. 10. I dislike it that way.

Table 1- Functional and dysfunctional question in the Kano questionnaire. Source: (Sauerwein et al., 1996)

By combining the two answers in the following evaluation table, the product features can be classified.

Customer requirements		Dysfunctional (negative) question				
		1. like	2. must be	3. neutral	4. live with	5. dislike
Functional (positive) question	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. live with	R	I	I	I	M
	5. dislike	R	R	R	R	Q

Customer requirement is ...

A: Attractive
M: Must-be
R: Reverse

O: One-dimensional
Q: Questionable
I: Indifferent

Table 2- Kano evaluation table. Source: (Sauerwein et al., 1996)

For further information I recommend the original Kano article (Kano et al., 1984), it is not available in the databases and difficult to find. There is an other article worth reading article about the topic; the special issue from 1993 in the Center for Quality Management Journal, which is an extensive compendium of ideas and experiences from using Kano theory of attractive quality. This represents one of the most comprehensive and valuable articles on the subject. Even

Professor Kano himself contacted the CQM journal and asked for additional copies for teaching (Burchill et al., 1994) quoted by Witell and Löfgren (2007).

PERCIEVED PERFORMANCE MEASUREMENT

In the literature, all agree that some measure of perceived performance is important in assessing service quality. What is apparent is that the debate over how best to measure service quality is far from complete (Robinson, 1999).

Model selected, SERVQUAL.

It is now nearly two decades since the SERVQUAL instrument appeared in the literature. (Parasuraman et al., 1985). According to Robison, 1999, there seems little doubt that in the past decade SERVQUAL has proven to be the most popular instrument for measuring service quality. In 1985, Parasuraman et al. developed the SERVQUAL instrument (refined in 1988, 1991 and again in 1994). The instrument consists of two sets of 22 statements: the first set aims to determine a customer's expectations of a service firm; while the second set seeks to ascertain the customer's perceptions of the firm's performance. The results of the survey are then used to identify positive and negative gaps in the firm's performance on five service quality dimensions. (Robison, 1999)

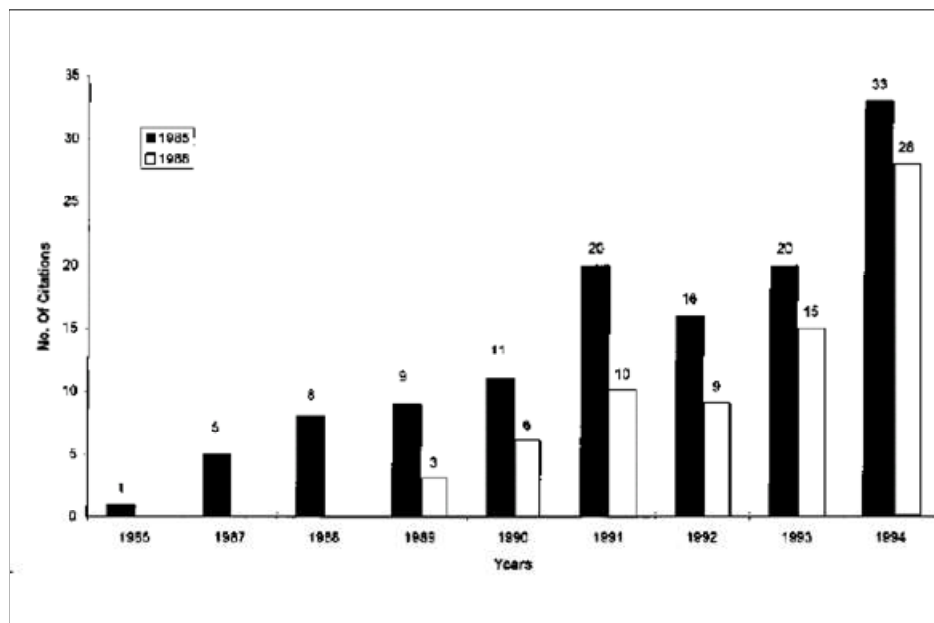


Figure 8- Citations of Parasuraman et al. Papers (1985, 1988). Source: Philip and Hazlett (1996). Most of the articles modify or criticize the SERVQUAL instrument.

Zone of tolerance

Berry and Parasuraman, 1991 defined the zone of tolerance:

The zone of tolerance is a range of service performance that a customer considers satisfactory. A performance below the tolerance zone will engender customer frustration and decrease customer loyalty. A performance level above the tolerance zone will pleasantly surprise customers and strengthen their loyalty.

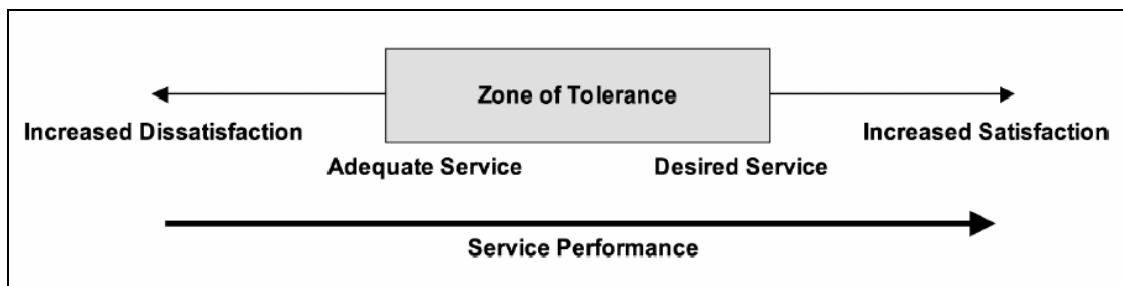


Figure 9- Zone of tolerance in service performance

Several authors (e.g. Johnston, 1995; Cronin, 2003) consider that levels of service performance within the zone of tolerance are not perceived as different by customers. Other authors establish a distinction between zone of tolerance and zone of indifference. According to Wirtz and Mattila (2001), when performance falls within the zone of tolerance but outside the zone of indifference, consumers might begin to perceive the deviation from mean expectations. Nevertheless, the authors also state that "this perception of disconfirmation is likely to be minimal since performance remains within acceptable or tolerable ranges" (Puga-Leal and Pereira, 2007).

In this thesis we will follow Johnston's, (1994) ideas that within the ZOT the customers may accept variation within a range of performance and any increase in performance within this area will only have a marginal effect on perceptions. (Strandvik, 1994)

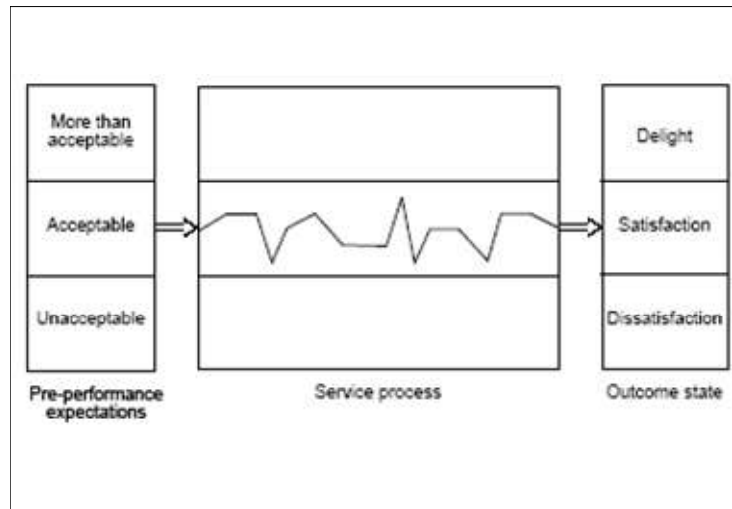


Figure 10- The variation inside the zone of tolerance may not be noticed Source: (Johnston, 1994)

Three categories of quality characteristics are generally considered (e.g. Ross, 1988) in most practical applications: nominal-is-best (e.g. time schedules), higher-the-better (e.g. computer's performance) and lower-the-better (e.g. waiting time in a queue). While the first one needs two specification limits, the second only has a lower specification limit and the last one an upper specification limit (Puga-Leal et al., 2007).

Parasuraman et al. claim that SERVQUAL is both a reliable and a valid measure of service quality (Parasuraman et al., 1988; 1991; 1993). Despite its popularity, a number of critiques is leveled at the SERVQUAL instrument, aimed at both the conceptual and the operational level (Robison, 1999). See for example Babakus and Mangold (1989), Cronin and Taylor (1992), Finn and Lamb (1991), Kuei and Lu (1997). One of the issues in this debate is that SEVQUAL does not provide good measures of the importance of service attributes and dimensions (DeSarbo et al., 1993).

SERVQUAL 1-COLUMN									
-----'s Service Performance Is:									
	Lower than my desired service level			The Same As My Desired Service Level			Higher Than My Desired Service Level		
When it comes to...									
1. Prompt service	1	2	3	4	5	6	7	8	9
To policy holders									

SERVQUAL 2-COLUMN																		
When it comes to...	Compared to My Minimum Service Level _____'s Service Performance Is:					Compared to My Desired Service Level _____'s Service Performance Is:												
	Lower			The same		higher			Lower			The same		higher				
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
To policy holders																		

SERVQUAL 3-COLUMN																				
When it comes to...	My Minimum Service Level Is:					My Desired Service Level Is:					My Perception of _____'s Service Performance Is:									
	Low		High			Low		High			Low		High							
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9		
To policy holders																				

Figure 11- One column SERVQUAL format provides no information about the zone of tolerance. The two-column format scores can indicate whether the perceived service level is above the tolerance zone, below the tolerance zone or within the tolerance zone. The Three-column SERVQUAL format is capable of specifically indicating the position of the zone of tolerance and the perceived service level relative to the zone. Source: (Parasuraman et al., 1988)

SERVQUAL BATTERY	
Reliability	
1.	Providing services as promised
2.	Dependability in handling customers' service problems
3.	Performing services right the first time
4.	Providing services at the promised time
5.	Maintaining error-free records
Responsiveness	
6.	Keeping customers informed about when services will be performed
7.	Prompt service to customers
8.	Willingness to help customers
9.	Readiness to respond to customer's request
Assurance	
10.	Employees who instill confidence in customers
11.	Making customers feel safe in their transactions
12.	Employees who are consistently courteous
13.	Employees who have the knowledge to answer customer questions
Empathy	
14.	Giving customers individual attention
15.	Employees who deal with customers in a caring fashion
16.	Having the customer's best interest at heart
17.	Employees who understand the needs of their customers
18.	Convenient business hours
Tangibles	
19.	Modern equipment
20.	Visually appealing facilities
21.	Employees who have a neat, professional appearance
22.	Visually appealing materials associated with the service

Figure 12- The SERVQUAL battery consists of 22 questions within 5 different areas. Source: (Parasuraman *et al.*, 1988)

A number of others also enter the debate on service quality measurement, for instance, Babakus and Boller (1992), Boulding *et al.* (1993), Bolton and Drew (1991a), Brown *et al.* (1993), Buttle (1996), Carman (1990), Genestre and Herbig (1996), Iacobucci (1996), Lam and Woo (1997), Morrison (2004), Lewis and Mitchell (1990), Mels *et al.* (1997) and Smith (1995). In return, Parasuraman *et al.* defend their approach while also making changes to the SERVQUAL instrument in response to the criticisms and additional empirical research.

TARGET SETTING

Puga-Leal and Pereira model

Puga-Leal and Pereira, (2007), developed the only exiting model in the literature to translate customer expectations into specification limits in services. The model is an integration of SERVQUAL and QFD. They use the SERVQUAL 3 column model.

	My minimum service level	My desired service level	My perception of DirectXYZ performance
	Low High	Low High	Low High
Waiting time for a phone-call to DirectXYZ	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Figure 13- Puga-Leal and Pereira, (2007) use SERVQUAL 3-column in their model

The output of SERVQUAL 3-column is the minimum service levels and the desired service level (zone of tolerance) and the perceived performance of the different customers. With the perceived performance distribution of the answers in points (from 1 to 9 points), they plot the histogram and set the zone of tolerance with the average value of the minimum service level (LSL) and desired service level. Then they translate these limits into the real performance distribution (in seconds).

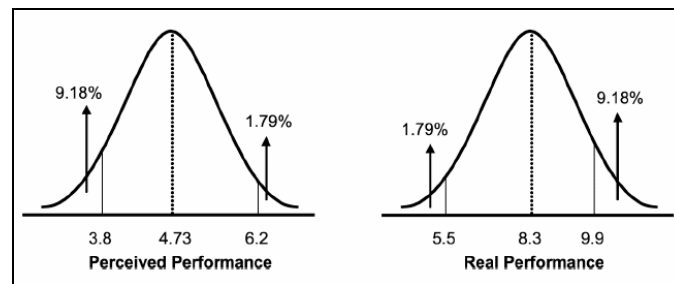


Figure 14- The distribution is plotted based on the answers in the perceived performance (in points) and the limits are translated into the real performance distribution

We contacted Rogerio Puga-Leal by email; he recommended some literature for the topic. He wrote that this approach is the only one in the literature to systematically translate customer expectations into specification limits. We think that this is a good conceptual model, but applied in the reality we doubt of its robustness and consistency. This model considers that all the quality attributes are one-dimensional. For example if the distribution of the actual performance is an exponential distribution, the transformation would not be realistic. Also we think that the perceived performance distribution in points can be totally different from the real performance. For these reasons we decided not to use this model.

Model selected, the Taguchi loss function

Genichi Taguchi developed the foundations of Robust Design in the 1950s and early 1960s. Taguchi methods are claimed to have provided as much as 80 per cent of Japanese quality gains. Traditionally, quality is viewed as a step function, this view assumes that a product is either good or bad and is uniformly good between the upper and lower specifications. However, in practice products will vary on a performance scale and samples of products would more likely show a curve rather than the step line. The loss function establishes a financial measure of the user dissatisfaction with a product's performance as it deviates from a target value (the most desirable value of the parameter under consideration). It puts the customer at the centre of the issue (Lofthouse, 1999).

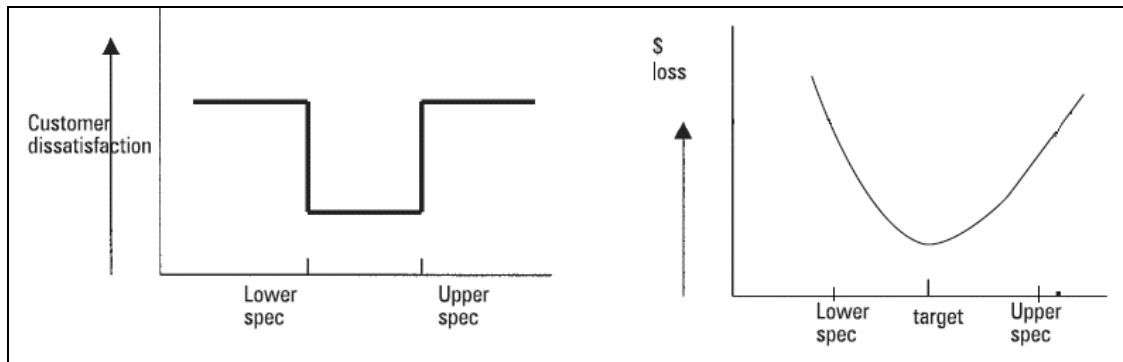


Figure 15- a) Traditional view b) Taguchi loss function. Adapted from Lofthouse, (1999)

Taguchi ideas are useful to set the specification limits. If we define the loss as the customer dissatisfaction, we can set the specification limits when the dissatisfaction levels are out of the ZOT. Taguchi ideas are important to understand that the closer to the optimal satisfaction value the better. It is not enough to be within the specification limits, it is important also that the distribution is centered. We decided to use Taguchi ideas. For further details see Taguchi, (1987) or Phadke, (1989), for a short general overview with down-to-earth language see Lofthouse, (1999).

Benchmarking

The basic idea is to make a careful comparison of a process of the company with the same or a similar process at another company or another division of one's own company and benefit from the comparison. In Japanese, the corresponding concept is called dantotsu, which means roughly "striving to be the best of the best" (Bergman and Klefsjö, 2003).

Whereas SERVQUAL is an instrument to measure subjective performance measurement, Benchmarking is a tool to measure objective performance measurement. Harrington (1991) claims that benchmarking provides realistic targets for performance improvement and helps convince skeptical employees that the targets set by management are credible and attainable, at least by other companies (Wash, 2000).

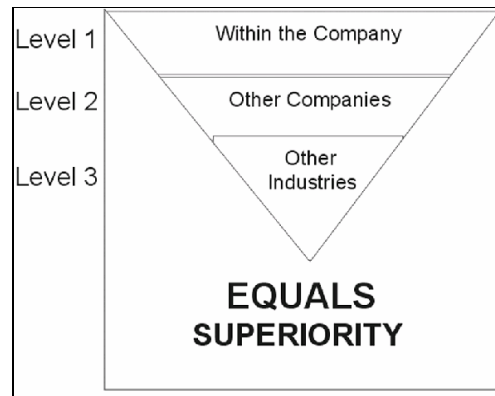


Figure 16- The objectives of success using benchmarking, adapted from McCabe, 2001 by Beatham, 2004.

We are setting the specification limits for internal measures made with SPC; it is rather difficult to do a realistic benchmarking because they are not standardized. We will not use this approach.

Quality Function Deployment (QFD)

Quality Function Deployment was developed in Japan, by Yoji Akao, in 1972. QFD serves as a planning process for translating customer needs into appropriate organizational requirements (Tan and Pawitra, 2001).

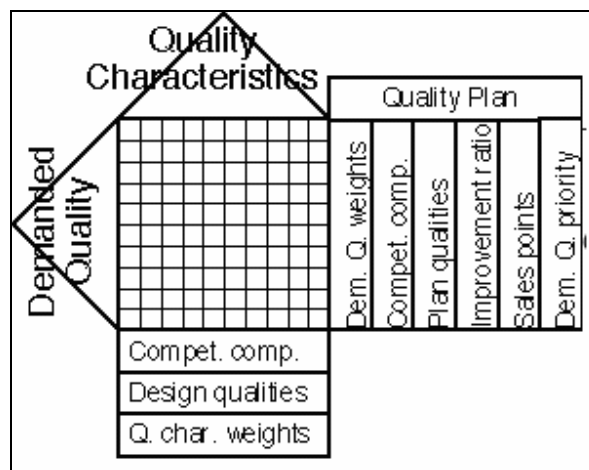


Figure 17- The quality house is a tool that facilitates QFD work. It is an approach to systematically transform customer expectations into measurable values. Source: Bicheno, (1998)

QFD is a good tool for product development and in cases with a big number of attributes. It is not useful in our case it is not useful because it is too systematic. According to Bochareau and Rowards (1999) QFD is imprecise for setting target values and it assumes linearity. For further details see Cohen, (1995).

Model selected, the importance performance Analysis (IPA)

This subsection is based on Tontini and Silveria, (2007). The Importance Performance Analysis (IPA), introduced originally by Martilla and James (1977), allows a company to identify which attributes of its product or service should be improved to become more competitive in the market. Typically, data coming from customer satisfaction surveys are used to build a matrix, where the importance is shown by the y-axis and the performance of the attribute by the x-axis (Figure 19). In the traditional IPA (Figure 19(a)), the matrix is divided into four quadrants. One possible disadvantage of this quadrant approach is that “a minor change in the position of an attribute can lead to a dramatic change in the attribute’s inferred priority” (Eskildsen and Kristensen, 2006). Slack (1994) proposes a different way to analyze the IPA matrix, dividing it into non-symmetrical action zones (Figure 19(b)). Slack’s approach allows for a more continuous transition in the inferred priorities (Eskildsen and Kristensen, 2006) and the reasoning behind it is that customers could accept lower performance in less important attributes and require higher performances of more important attributes.

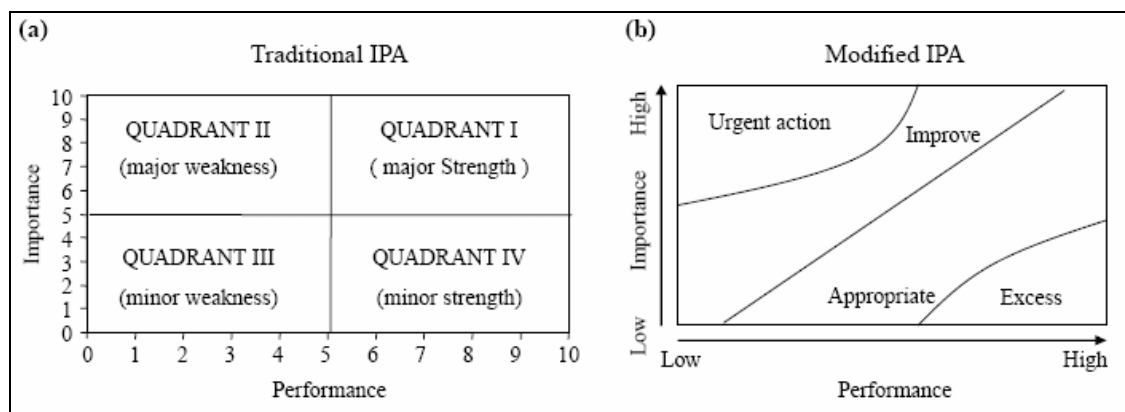


Figure 18- Traditional IPA originally from Martilla and James (1977) and the modified IPA originally from Slack (1994). It is an useful tool to detect which attributes could be improved.

Although the IPA model of quality attributes is a simple structure, it can provide much useful information about a company’s quality performance. IPA will be used in the model. The disadvantage of this methodology is that the results normally are quite obvious. For example if the performance is low and the importance is high, it is not difficult to notice that something must be done. More than a strict strategy model, we think that it is a good visual classification to know the actual position of the attributes.

ATTRIBUTE IMPORTANCE

“Customers usually evaluate product and service quality according to the attributes that they consider to be important.”

Deming, 1986

When visiting your doctor, getting the proper diagnosis and treatment seems more essential than having a good selection of magazines available in the waiting room, though both may be necessary for a favorable experience (Walker and Baker, 2000).

Customers may consider some features of a service as more necessary or essential to their experience than others. It is therefore important to measure the attribute importance. In the literature there are several approaches to do it; the most frequently mentioned are conjoint analysis, Kansei engineering, self-stated questionnaire and importance ranking. The attribute importance is the most difficult classification. The customer tends to consider everything important; we call it the “everything is important” problem. The questionnaire must be done in such a way that the customer has to select which is relatively more important; he/she must be forced to decide in a hypothetical scenario which is the most convenient option.

Conjoint analysis

Conjoint analysis methodology is built on statistical design of experiments with the use of simple factorial designs. Potential users are asked to rank the different product concepts in order of preference, where important factors are chosen according to a factorial design with factors chosen at two levels (Bergman and Klefsjö, 2003). Normally it is used for analyzing trade-offs. The output of this analysis are the significant factors and their effect, therefore the different attributes can be graded according to its importance. (for further details, see Green and Srinivasan, (1978, 1990); Louviere, (1988)), for an example of application in services, see Liljander and Strandvik, (1993) where they set the zone of tolerance from a conjoint analysis in restaurant services.

- | |
|--|
| <ul style="list-style-type: none">(1) Characteristic of education<ul style="list-style-type: none">• Wide (contains a complete overview of the quality area with some focus)• Deep (focus completely on selected areas)(2) Focus on education<ul style="list-style-type: none">• Hard (focus on statistical methods)• Soft (focus on leadership and organizational development) |
|--|

Figure 19- Example of a conjoint questionnaire used by Gustafsson et al., (1999) for analyzing the characteristics of education at Linköping University

We started to investigate about conjoint analysis. We thought that it could be a useful and powerful tool. We thought that the fact of showing different scenarios to the customers would be the solution for the “*Everything is important*” problem. We did one 2^k full design for internal and other for external customers attributes. It is a 2^{k-1} design with 2^3 different combinations. The design had two levels for example:

(+) *High on-time delivery*

(-) *Low on-time delivery*

From the 8 different combinations, two could be omitted for the obvious customer selection. The customers were intended to rank the 6 different scenarios in order of preference. We tested it and we realized that it was too long and difficult to answer. To overcome the difficulty of ranking 6 different combinations, we thought about asking them to rate the combinations in pairs. It is an easier solution.

But we realized that conjoint experiments is an useful tool in trade-off solving. In this case all the variables are independent, therefore the interactions are not significant and the only result that we had is the importance of the attributes. If we are not interested in the level-2 interactions then a factorial design must be used. In the factorial design there are 4 different combinations. We realized that selecting these different combinations the only thing we were asking is: rank the 3 attributes in order of importance but in a complicated way and with a lot of noise in the answers. Then the question was: Are we complicating it too much? Would we have the same results just asking the customer: Rank in order of importance the following 3 attributes? Finally after various discussions we decided not to use conjoint experiments in the model. However the conjoint analysis idea of showing different scenarios to the customers was the basis of the new model, “*the trade-off importance model*”.

Kansei engineering

Kansei is a Japanese word. It is difficult to translate. It means approximately “*total emotions*”. Kansei is the impression somebody gets from a certain artifact, environment or simulation using all their senses of sight, hearing, feeling, smell, taste as well as their recognition (Nagamachi, 2001) quoted by Schütte, 2003. This method can be applied to services. The customers are asked to rank different services scenarios and the way to analyze it is similar to conjoint analysis. For the same reasons explained in previous section we decide not to use Kansei engineering model. The outputs are the different effects of the factors and therefore the importance of the different attributes can be calculated. For further details see Schütte, 2002, 2004, 2005.



Figure 20- Example of Kansei applied to investigate different web pages; the customer is asked to rate in a continuous line the different attributes. Research made by Linköping Institute of Technology Kansei group.

Self-Statement Importance Questionnaire

According to research by Hauser, (1988), the Self-stated Importance questionnaire can help organizations understand the relative importance of each requirement for customers (Shen, 1993). The attributes can be graded according to its importance. In this case we do not think that it is a useful tool because of the “everything is important problem”, customers tend to rank all the attributes as important and it does not give an accurate information about the relatively importance.

	Not at all important		Somewhat important		Important		Very important		Extremely important	
<i>How important is it or would it be if: The car has good gas mileage?</i>	1	2	3	4	5	6	7	8	9	
<i>How important is it or would it be if: The car has good brakes?</i>	1	2	3	4	5	6	7	8	9	
<i>How important is it or would it be if: The car has a long warranty period?</i>	1	2	3	4	5	6	7	8	9	
<i>How important is it or would it be if: The car has a small turning radius?</i>	1	2	3	4	5	6	7	8	9	

Figure 21- Example of a Self-Statement Importance Questionnaire. Source: (Shen, 1993)

Attribute importance rating

According to Pyzdek, (2003) the ranking format is used to rank options according to importance. Ranking formats are difficult to write and to answer. The limitation of this approach is that there is not information about the relative importance of the attributes. In the doctor example you have as a result that the right diagnosis is more important than a good selection of magazines but not how much more important therefore, we decided not to use this approach.

Model Selected, new model

We find it very important to extract the customer opinion about the relatively importance of attributes. The models in the literature are incomplete and not useful for this purpose. We developed a new approach for relative importance measure, the Importance Trade-Off analysis. The basic idea of the model is that when explicit trade-offs between elements of the customer service mix are taken into account, different components of relative importance emerge (Wetzels et al., 1995). See appendix II- for further details.

CONCLUSION

Service quality is evaluated by customers only. The characteristics of the services (intangibility, heterogeneity, perishability, difficulties in standardization, and their simultaneous production, delivery and consumption) make the evaluation of service quality a complicated matter (Shetty and Ross, 1985).

For this reason, there is not an agreement of which is the best way to measure service quality in the extent literature about service quality measurement. The most popular and used models in industry receive a lot of criticism. Robinson, (1999) claims that since the understanding of service quality is so limited it seems unrealistic to be aiming for a global measurement approach until a much better understanding is obtained. The debate is far from complete.

The different approaches have been presented and organized in four categories. From each category one model has been selected always having in mind our specific needs. This section serves as a baseline from section II -disadvantages of every model working separated- and section III –Model Construction-. In the next table there is a summary of the models presented and selected.

Classification of quality attributes	Kano 5- level Kano 3- level Classification through direct questions Classification via importance
Perceived performance measurement	SERVQUAL Others
Target setting	Puga-Leal and Pereira, (2007) model Taguchi loss function Benchmarking Quality function deployment Importance performance analysis
Attribute importance	Conjoint experiments Kansei engineering Self-States questionnaire Attribute importance ranking New approach

Table 3- Summary of the different approaches presented. Selected approaches are given with bold letters

SECTION II

An integrated approach, using the Kano model, SERVQUAL, Importance Performance Analysis (IPA), Trade-Off Importance analysis and Taguchi ideas

The provision of poor service quality is a familiar experience for most of us. In the literature, all agree that some measure of service quality is important. What is apparent is that the debate over how best to measure service quality is far from complete (Robinson, 1999). There can be found an extent amount of research papers criticizing and modifying the different models separated, or combining two different models. The objectives of this section are: (i) to synthesize and organize the extant literature on the criticism and problems of the different models selected; (ii) To present the problems of each model for the company needs (iii) to justify the necessity of an integrated approach; and (iv) to serve as a guide for further reading and researching.

INTRODUCTION

“The research challenge into service quality is, and will continue to be, ongoing; many “grey” issues will have to be addressed and resolved.”

Philip and Hazlett, (1997)

The key measure of every organization is not effectiveness, efficiency, profit, growth, satisfaction, loyalty nor even market value or share. Each of these depends on one key measure; that measure is how well the organization meets the customer needs (Harris and Harrington, 2000). It makes no sense to minimize total costs if at the same time customer relations are being eroded (Johnston et al., 1994). There is an agreement in the literature that the characteristics of service make it difficult to quantify service quality.

Witell and Löfgren (2007) made a literature review with 29 research articles; they found that the theory of attractive quality is often used in combination with other methods, for measuring quality or developing new products. The most interesting finding, however, was that most empirical studies on the theory of attractive quality have modified the methodology and/or devised novel ways to classify quality attributes.

Several authors highlight the problems of the different models, by integrating and adapting the different model in the literature to the specific company needs we strive to construct a robust model for service excellence deployment with the final target of setting the specification limits. The problems of using the models selected in previous section are presented and the need of an integrated approach is analyzed.

Benefits and problems of the Kano model

Considering Kano's model, one sees how it may not be enough to merely satisfy customers by meeting only their basic and performance needs. In a highly competitive marketplace, organizations need to adopt strategies and to create product attributes targeted specifically at exciting customers and over-satisfying them. (Tan and Pawitra, 2001)

Based on publications of Kano's model, Matzler and Hinterhuber (1998) summarized its following benefits:

- Kano's model promotes understanding of product/service requirements. The attributes that have the greatest influence on customer satisfaction can be identified.
- It provides valuable guidance in the following trade-off situation. If two product attributes cannot be promoted simultaneously due to technical or financial reasons, the attribute that has greater influence on customer satisfaction, can be determined.

- The use of Kano's model can lead to developing a wide range of product/service differentiation by examining the attractive attributes. The attractive attributes are the key to beating the competition in the marketplace.

Despite the above benefits, Kano's model is restricted by several limitations

- It is a pure qualitative model. It does not represent the actual performance.
- Kano model does not represent the Zone of Tolerance
- It can be used only in more is better attributes
- It does not analyze the relative importance of the attributes
- It does not have a guideline for strategic directions

Benefits and problems of SERVQUAL

Tan and Pawitra, (2001) summarized the benefits of SERVQUAL as follows:

- It is good at eliciting the views of customers regarding service encounters, e.g. expectations, and satisfaction.
- It is able to alert management to consider the perception of both management and customers.
- Addressing the service gaps can serve as a basis for formulating strategies and tactics in order to ensure the fulfillment of expectations.
- SERVQUAL is able to identify specific areas of excellence and weaknesses.
- It provides benchmarking analysis for organizations in the same industry.

Despite SERVQUAL's wide use by academics and practitioners in various industries in different countries, a number of studies had questioned its conceptual and operational bases. According to Tan and Pawitra (2001) for service excellence development, three areas for further improving SERVQUAL can be identified.

First, SERVQUAL assumes that the relationship between customer satisfaction and service attribute is linear. The implication is that low customer satisfaction result from low attribute performance, and that this should be the focus for improvement. This is not necessarily true however. Paying more attention to a particular service attribute (e.g. assuring the customer) may not always lead to higher satisfaction if there is satisfaction or if that attribute is taken for granted. Complimentary, customer satisfaction can sometimes greatly improved with only a small improvement of a service attribute that is unexpected or delightful. SERVQUAL's use of a linear scale in its assignment of prioritization for improving service attributes may, therefore, not be appropriate in certain cases.

In addition, SERVQUAL is recognized as a continuous improvement tool. There is however, no element for innovation. However, with increasing market pressure, continuous improvement may

not be sufficient in maintaining a competitive edge. Many organizations are strategically moving towards innovation in order to achieve increase competitiveness (McAdam *et al.*, 2000).

Third, SERVQUAL provides important information on the gaps between predicted service and perceived service. However, it is not able to address how the gaps can be closed. It would be good if SERVQUAL can be integrated with other service quality tools that are more focused on reducing the service gaps.

Additionally, we think that even if the user-friendly format of SERVQUAL has helped made it into an industry standard (Losa *et. Al.*, 1998) the SERVQUAL question battery is a rigid template that can not be useful in specific applications. In our case we are just interested in the perceive performance of 6 attributes. Hence is important to tailor SERVQUAL. It is a qualitative model. We agree with the some criticism in the literature and we doubt its robustness used alone. Because it is too comprehensive, it can-not be classified as “user friendly”.

The significance of the integrated approach

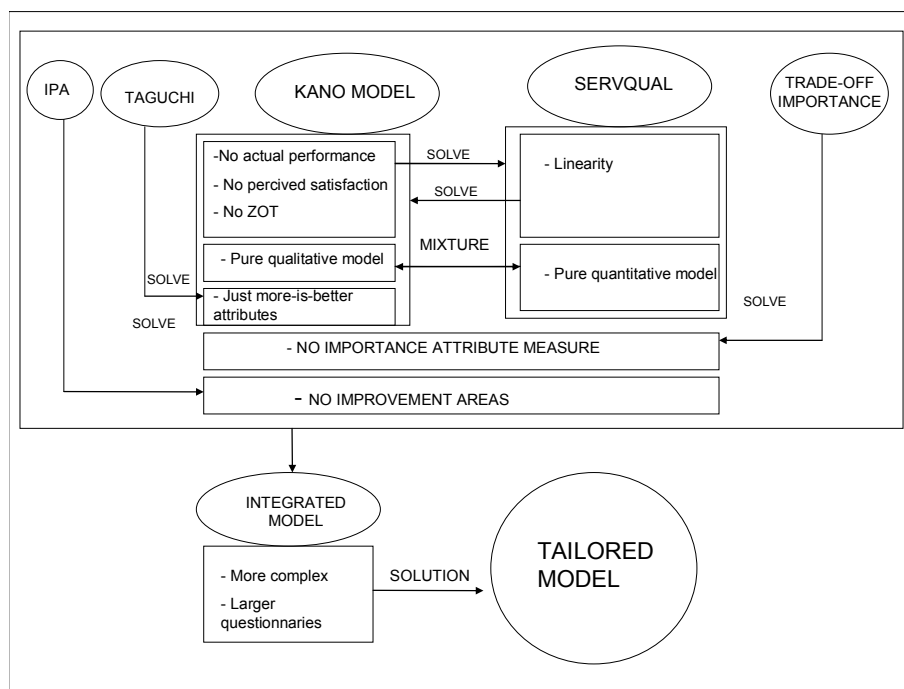


Figure 22- Problem analysis of the different models

The Kano model can help address the innovation issue against SERVQUAL. Because attractive attributes are a source of customer delight, this is one area where efforts for improvement should be targeted (Tan and Pawitra, 2001). Introducing Kano model into SERVQUAL can counter the linearity problem. SERVQUAL can help adding the actual performance, the perceived satisfaction and the ZOT into the Kano model. SERVQUAL is a purely quantitative model

whereas Kano model is a pure qualitative approach, an integration would be the correct mixture. Integrating SERVQUAL and Kano model, some problems have been addressed. However, there still remain:

It just consider more-is-better attribute:

Taguchi, (1987) considered four categories of quality characteristics: higher-the-better (e.g. computer's performance), lower-the-better (e.g. waiting time in a queue), nominal-is-best (e.g. time schedules) and asymmetric. The Kano model just take into consideration the more-is-better attributes. By introducing Taguchi ideas, the new model will take into account the four categories presented previously. If we define the quality loss as the customer dissatisfaction, by inverting the Kano lines we can represent the quality loss function, this loss function will valuable information about the qualitative associated costs depending on the company performance.

The relative importance of the attributes is not analyzed:

The Kano model and SERVQUAL have the disadvantage that they do not analyze the relative importance of the attributes. By integrating the new Trade-Off Importance model the information about the relative importance is obtained. For further details about this model construction, see appendix x.

No improvement directions:

Kano model and SERVQUAL do not have any strategic direction approach for guiding after the results. The IPA, together with the Kano classification helps to guide to the improvement directions.

More complex analysis and large questionnaires

In the literature there are several articles that integrate SERVQUAL into Kano Model, for example, Yang, (2003), and Tan and Pawitra, (2001), both of them fail in one of the most important things, they are time consuming to answer and analyze. Therefore, it is of paramount importance a new simplified integrated approach is developed from the different models. One important restriction is that even if we are applying five different models, the time to do the questionnaire and the analysis must be easy and quick.

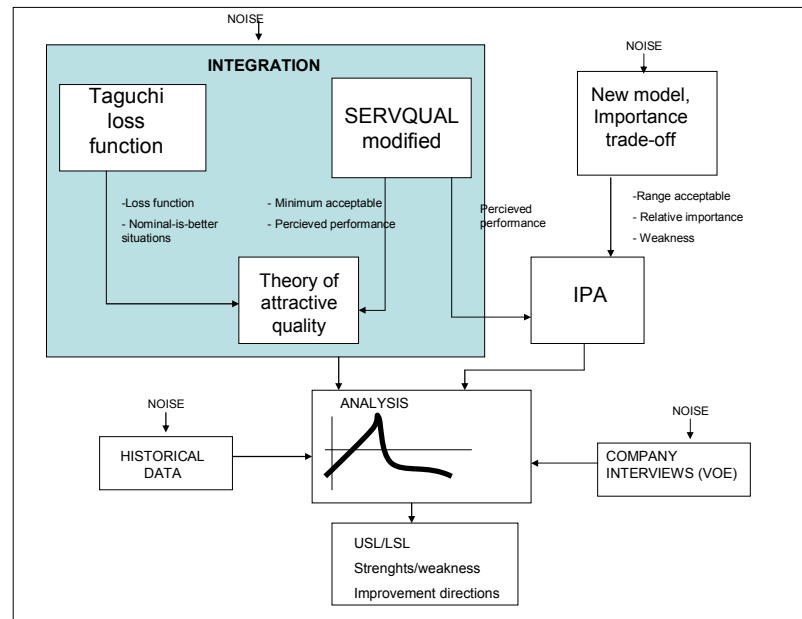


Figure 23- Our tailored model

The integrated approach would increase the utility of either method compared to if they were used separately. By means of the questionnaire evolving SERVQUAL modified, Kano modified and Importance trade off, we seek to extract the customer needs. It is important also to know the distribution of the actual performance in all the attributes (Voice of the Data) and interview people in the company to gather the voice of experience. The evaluation of service quality is something subjective; we take into account the noise present in the data gathering and application of the model. All this information is analyzed and the outputs of the model are the specification limits (USL/LSL) for the six attributes, the improvement areas and target values.

Conclusion

To understand and provide the requirements of customers is becoming the core of quality activities for enterprises (Yang, 2003). In the literature all agree about the difficulties of measuring service quality and the deficiencies of the different methods.

The main conclusion of this section is that the theory of attractive quality is purely qualitative and must be combined with other quantitative measurements. SERVQUAL is a quantitative model, it is a strict template that in our specific case is needed to modify. It assumes linearity, i.e. all the attributes are one-dimensional. The modification and combination of these two models to overcome these drawbacks will be the basis of the new model.

Kano model and SERVQUAL do not measure attribute importance and strategic improvement directions. By combining them with the trade-off importance model and IPA we strive to build a robust model for service quality deployment with the final target of setting the specification limits.

SECTION III

Formulation and construction of an integrated model for translating the customer needs into specification limits

Shewhart in 1931, differentiated the two sides of quality, subjective quality (customer needs) and objective quality (specification limits). Nearly 70 years later the more widespread and used model to link these two sides of quality is the Kano model. In the previous section the deficiencies and limitations of the Kano model have been presented and the need of an integrated approach was discussed. In the literature there are several research articles that integrate Kano and SERVQUAL models. All of them fail in one of the most important respect for a successful model. They are long and time consuming to answer and analyze. This is the first attempt to totally integrate and modify both models. The final approach is simple and systematic to analyze, with short questionnaires easy to answer (less than 5 minutes) and all the output information is compacted in an easy to understand graphic. It is the first attempt also to create a roadmap for translating customer expectations into specification limits.

Introduction

“If you think you know something about a subject, try to put a number on it. If you can, then maybe you know something about the subject. If you cannot then perhaps you should admit to yourself that your knowledge is of a meager and unsatisfactory kind.”

Lord Kelvin, (1893)

In his theory, Kano et al. (1984) aimed to link the two sides of quality defined by Shewhart, (1931), objective quality with the subjective quality. We agree with the ideas of the theory of attractive quality but we want to “*put a number on it*”, it is a pure qualitative approach. More than seventy years after the Shewhart differentiation of the two sides of quality the model to link these two dimensions is considered a “black box” (Lilja and Wiklund, 2006). This section aims to create a systematic approach to link in a quantitative way the subjective quality and the objective quality. This will allow the organization to “*break the customer code*”.

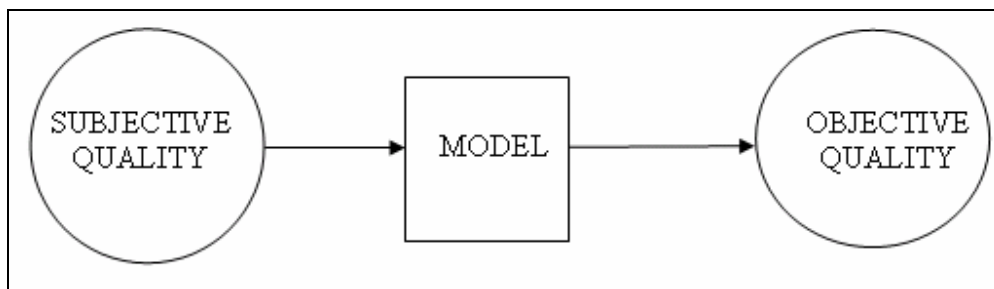


Figure 24- This section aims to create the model to link the two sides of quality defined by Shewhart more than 70 years ago

For doing it the need of an integrated approach was presented in the previous section. In the literature there are several articles that integrate SERVQUAL into Kano Model, for example, Yang, (2003), performs a survey with an integrated approach with a 7% of return rate. Tan and Pawitra, (2001) integrate SERVQUAL, Kano model and QFD and apply it to evaluate the image of Singapore from the Indonesian tourist perspective. These integrations are just using Kano questionnaire and SERVQUAL separated and an analysis with the information from both approaches. Tan and Pawitra (2001 p429) claim “*It is worthwhile especially for practitioners, to note the minimal amount of adaptation required of either methods*” but it leads to “*The integrated approach requires much manual work both for data input and output*”. According to Tan and Pawitra, (2001) the questionnaire takes 20 to 30 minutes to answer due to the use of two questionnaires. This is not a good questionnaire even if the results are relevant. It needs to be simplified.

A good model is the simplest possible model that adequately answers key-questions within a given deadline (Steins, 2006). NASA spent \$12 Million for the development of a space pen. When confronted with the same problem, the Russians used a pencil. This section aims to develop the “pencil” of the integrated approaches.

The suggested approach is to use the ideas of the theory of attractive quality, SERVQUAL and Taguchi to create a completely new model and combine it with the Importance Trade-Off model and IPA. The evaluation of service quality is something subjective; we take into account the noise present in the data gathering and application of the model. The modifications of the different models are presented and illustrated with one example.

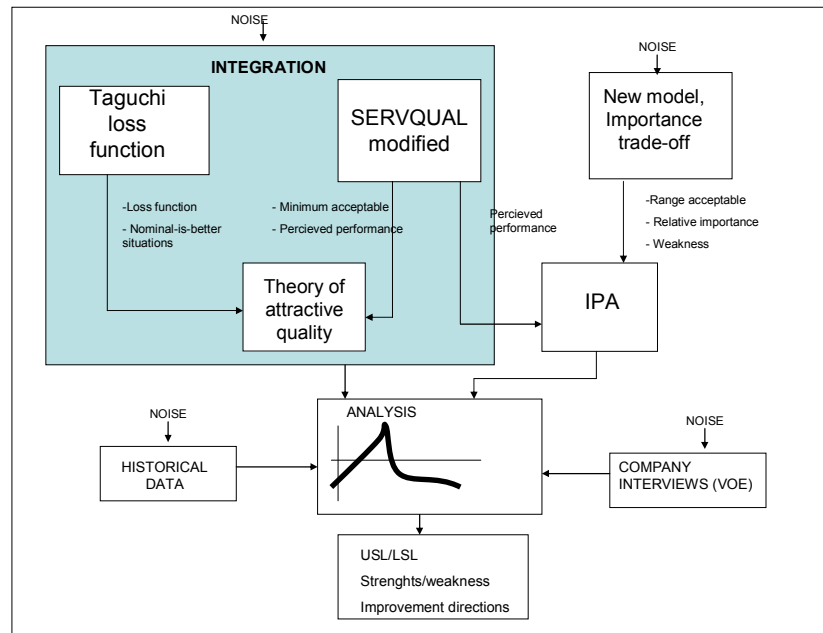


Figure 25- Proposed model

Preliminary assumptions

According to Johnston, (1994) the customer enters a service process with a consciously or subconsciously held view of what constitutes acceptable, less than acceptable and more than acceptable service. As the customer enters in a process through the various transactions in a service process, those pre-performance expectations are modified. The overall outcome is a state of satisfaction, dissatisfaction or delight.

A1a: Performance within the ZOT may be not noticed

The customers may accept variation within a range of performance and any increase in performance within this area will only have a marginal effect on perceptions. (Strandvik, 1994). For example, the customer would not notice the difference between 2 minutes and 3 minutes of waiting time in the queue of one supermarket because this values are within the ZOT.

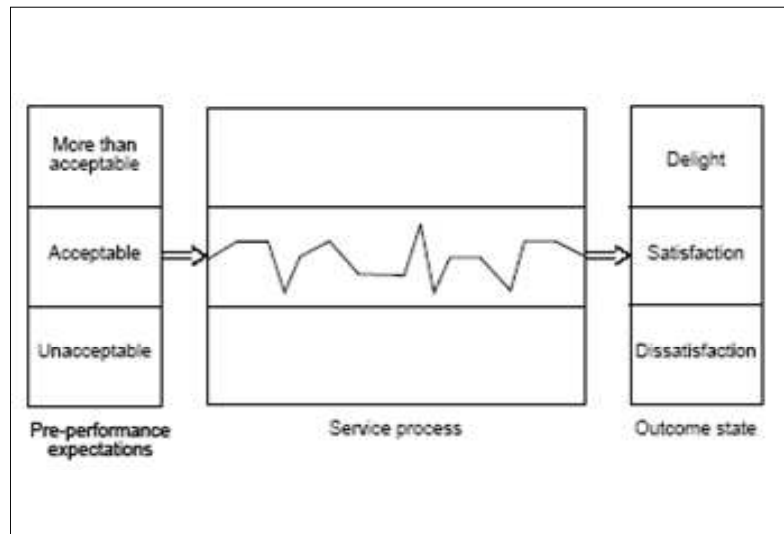


Figure 26- The variation inside the zone of tolerance may not be noticed Source: (Johnston, 1994)

A1b: Sufficient inclusions below the ZOT threshold will result in a dissatisfying outcome

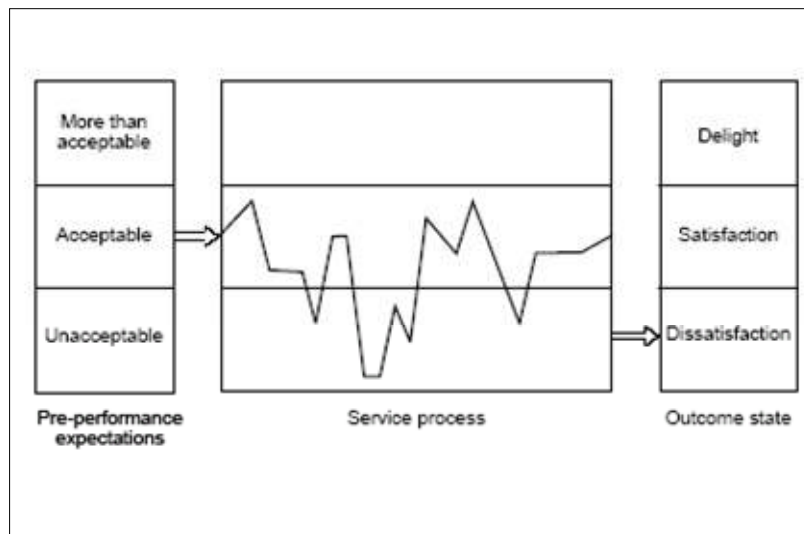


Figure 27- A dissatisfying process Source: (Johnston, 1994)

For example if for one customer the same airline cancels two different flights, the customer will always have a dissatisfaction outcome state of the service.

A1c: The ZOT with is inversely proportional to the degree of involvement

If one person is waiting in the emergency room with a slight injury, the range of waiting time until he can see the doctor is wide. If the same person has a serious injury the range of waiting time is narrow so the patient will have a small zone of tolerance.

SERVQUAL modification

SERVQUAL question battery is a rigid template with 22 questions in 5 different classifications. It can no be useful in specific applications. We are just interested in the perceived performance of 6 attributes. Hence it is important to simplify SERVQUAL.

SERVQUAL one-column format is a good tool to measure actual performance compared to the desired performance level. We decided to use this format (see example).

SERVQUAL 1-COLUMN											
-----'s Service Performance Is:											
Lower than my desired service level			The Same As My Desired Service Level				Higher Than My Desired Service Level				
			1	2	3	4	5	6	7	8	9
When it comes to...											
1. Prompt service											
To policy holders											

SERVQUAL 2-COLUMN									
Compared to My Minimum Service Level _____'s Service Performance Is:									
Lower			The same				higher		
1	2	3	4	5	6	7	8	9	
When it comes to...									
1. Prompt service									
To policy holders									

SERVQUAL 3-COLUMN																	
My Minimum Service Level Is:					My Desired Service Level Is:					My Perception of _____'s Service Performance Is:							
Low		High			Low		High			Low		High					
1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
When it comes to...																	
1. Prompt service																	
To policy holders																	

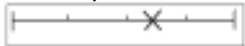
Figure 28- One column SERVQUAL is a compact way of asking the perceived performance compared with de desired performance level. The Three-column SERVQUAL format is difficult to analyze and understand.
Source: (Parasuraman et al., 1988)

In the three-column SERVQUAL the customer is asked for the minimum service level, the desired service level and the perceived service level. We use the one-column format to ask the desired and perceived service level in a compact and easy way. We modify the minimum service level measurement from the three-column SERVQUAL. We think that one scale in points from 1 to 9 it is quite abstract, relative and difficult to answer and analyze. Who will answer my minimum service level is... 1 (LOW)?

Instead we ask for the minimum service level in a continuous line with values and absolute units. We represent the scale from 0 to 30 days and from 0 to 3 months in all the attributes. It is done in that way to avoid the “green milk” problem. The majority of the people in Sweden buy the milk with green label because it is not fat and not light, is something in between. We were afraid that if we use the actual performance values in the scales i.e. one different scale for each attribute, the customers would answer in the middle. With the same scale for all of them they are forced to think where to set the limit. In some attributes it will be close to 0 and in others close to the maximum.

MINIMUM ACCEPTABLE SERVICE LEVEL

DIRECTIONS: Please, mark in the continuous line your minimum service level, in which you would start to be dissatisfied.
I would **START TO BE DISSATISFIED** if the attribute is bigger than:



SPARE PART QUOTATION delivery time	DAYS 0102030
INSPECTION REPORT delivery time	MONTHS 0123
Spare part DELIVERY BEFORE the requested date	DAYS EARLIER 0102030
Spare part DELIVERY AFTER the requested date	DAYS LATER 0102030

CURRENT SERVICE PERFORMANCE

DIRECTIONS: Based on your experiences with Siemens Service Division, think about the quality of service that we offer **compared with your desired service level** in the following attributes.

Falls short of
my desired
service level

Meets my
desired
service
level

Exceeds
my desired
service
level

INSPECTION REPORT delivery time	1	2	3	4	5	6	7	8	9
Spare-part DELIVERY ON- TIME	1	2	3	4	5	6	7	8	9
SPARE-PART QUOTATION delivery time	1	2	3	4	5	6	7	8	9
OVERALL PERCEIVED SERVICE PERFORMANCE	1	2	3	4	5	6	7	8	9

Figure 29- Final modification of SERVQUAL one-column and three-column

KANO MODIFICATION and integration into SERVQUAL

Theoretical issues of Kano's methods

In the special issue in fall 1993 of the *Center for Quality Management Journal*, Pouliot presents the following theoretical issue. Following the next assumptions, Pouliot, (1993) modifies the Kano model.

A2a: The word “like” is meant to be a very strong like, which in the limit becomes complete customer delight

A2b: The word “dislike” is as strong in the negative direction as “like” is in the positive direction.

A2c: The “must be” level is only a little above neutral because “must-be” is only a weak statement of satisfaction- it is more a statement of lack of dissatisfaction, though certainly more positive than neutral. Symmetrically, “can live with” is not a strong statement of dissatisfaction, but its gudging acceptance is more negative than neutral.

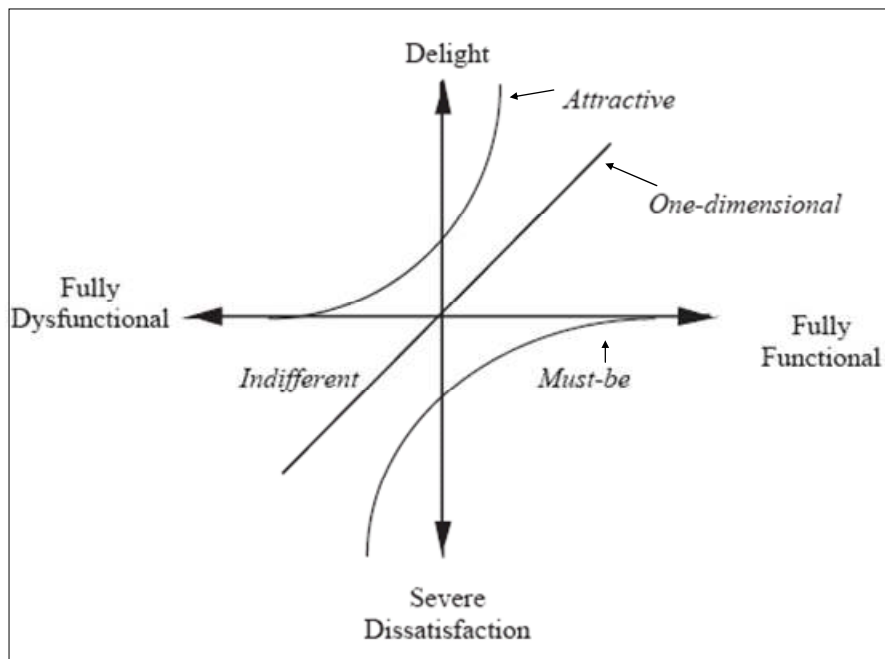


Figure 30- Kano original lines. Source: (Pouliot, 1993)

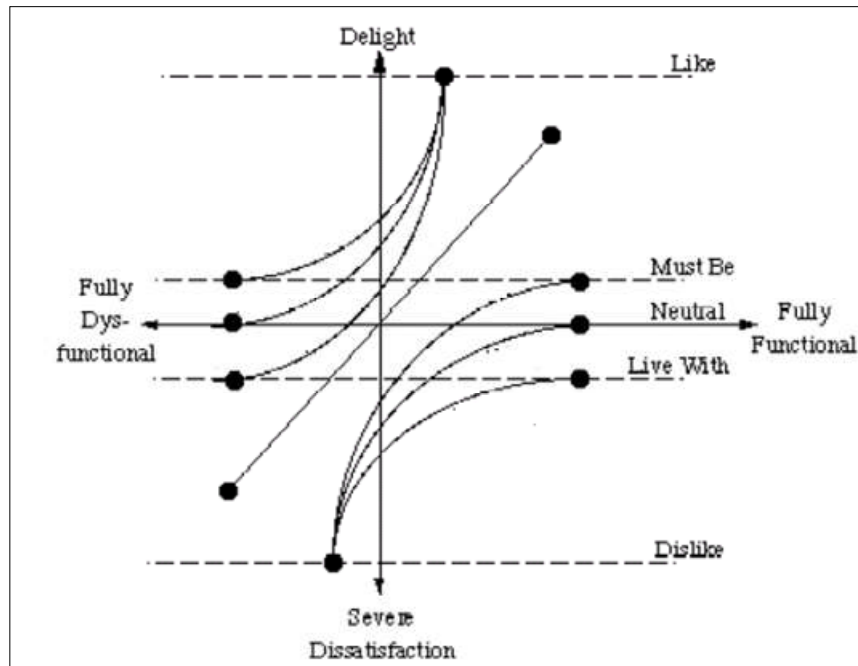


Figure 31- Proposed lines, observe that there is not only one line for every classification. Source: (Pouliot, 1993)

For every classification there are three different lines; Three for attractive, three for must-be and three for indifferent. Note that fully delight can be reached just with an attractive attribute and severe dissatisfaction just with a “must-be” attribute. A one-dimensional attribute can reach high satisfaction and dissatisfaction levels but not extreme levels. This is a most realistic and less qualitative view of the Kano model. It will be an important concept for our modified Kano model.

The Kano model does not represent the actual performance and the actual perceived satisfaction

The Kano model represents the performance-satisfaction but does not analyze the actual company position i.e. in which part of the graph the organization is situated. We modified the Kano model and we introduced numbers in the axes.

For the actual performance we introduce numbers and we represent the distribution of the actual performance. In the same way we introduced numbers in the satisfaction scale from 1 to 9. 1 is situated in “dislike”, 4 in “live with”, 5 in “neutral”, 6 in “must be” and 9 in “like”. With the SERVQUAL modified we can plot the normal distribution of the perceived performance. This is a good visual way to know where the company is situated in the curve.

Following the bus example, we write the minutes late, minutes early and on-time. From the historical data we represent the distribution of the actual performance. In this case it is a normal distribution, we can see that the mean of the departure is 3 minutes later than scheduled and just a few times the bus departs before scheduled. The bus driver normally waits until the scheduled time. In the other axis we represent the perceived satisfaction asked in customer survey with the modified SERVQUAL.

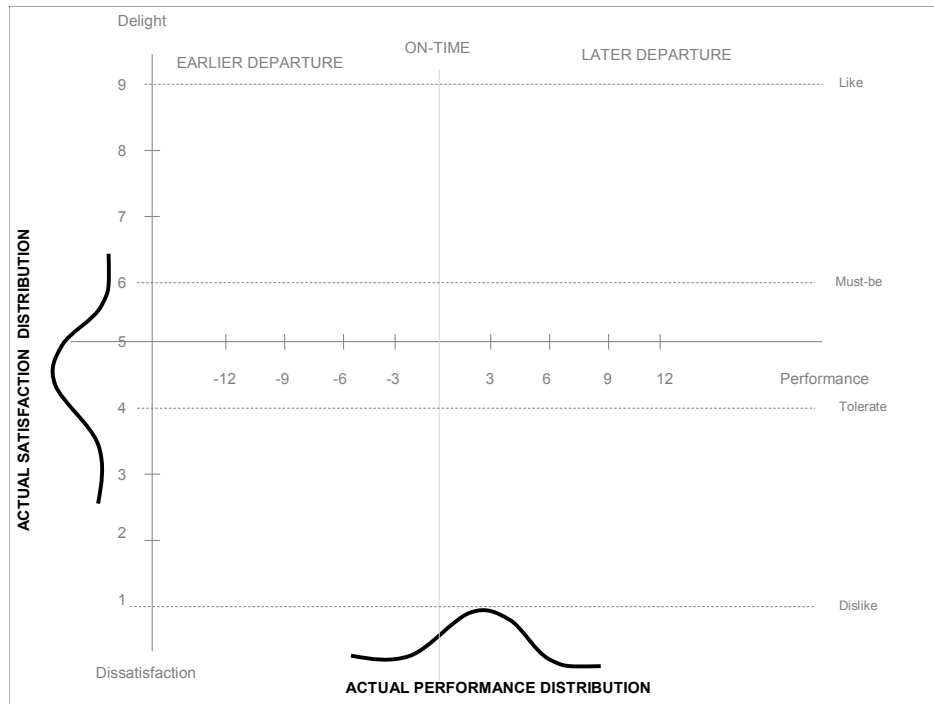


Figure 32- Introduction of the actual performance and the actual satisfaction in a bus departure example. The perceived satisfaction is between 3 and 6 points and the average is 4,5. This information is obtained with SERVQUAL.

Kano model does not represent the zone of tolerance

The Kano model does not represent the ZOT i.e. the range of service performance that the customer consider satisfactory. In the original 1984 Kano model the ZOT can be situated in the neutral line. With the modification explained in previous section we can set the zone of tolerance between the “must-be” line and the “live with” line. Inside this area the customers can accept variation without noticing. This assumption has a relationship with the fact that in the original Kano paper from 1984 if the customer answer “I can tolerate it” in the dysfunctional question and “It must-be like that” in the functional the Kano table classifies it as indifferent. With our modification it will be a line between “live with” (4-in satisfaction scale) and “must-be” (6 in satisfaction scale), as it is within the ZOT the customers would not notice the variations so we see that for them is indifferent.

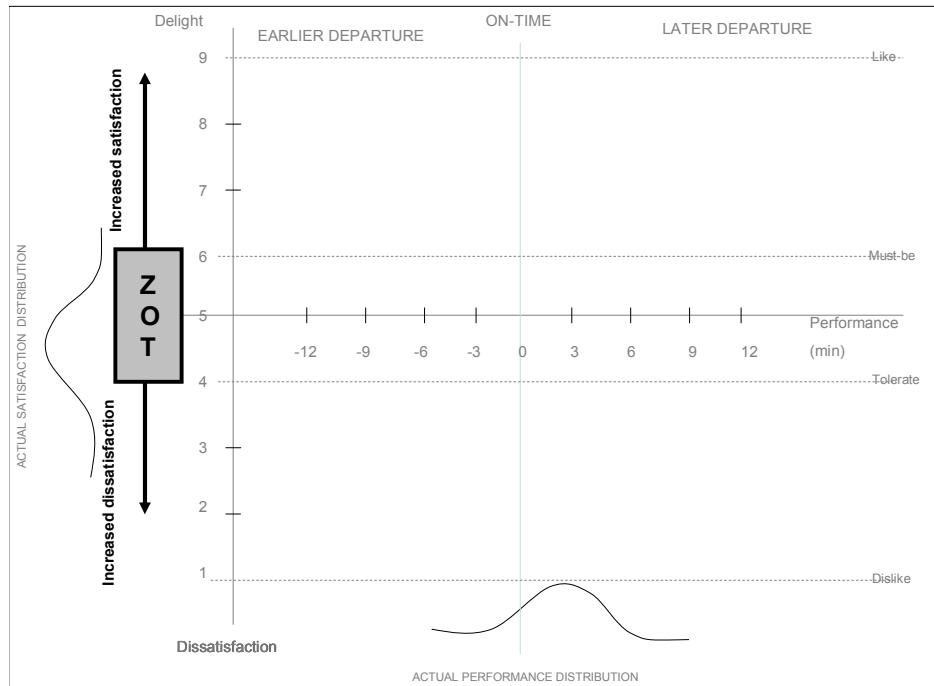


Figure 33- Introduction of the ZOT. We consider that the zone of tolerance is from 4 points to 6, i.e. from the “I can tolerate” line to “it must be like that” line

The vertical axis issue

The labels on the vertical axis are of great importance as they indicate the proposed effect of attractive quality elements. Kano et al. (1996) used the term “satisfied feeling”, referring to an affect, or an emotional state. Other representations of the model, however, use “customer satisfaction” (e.g. Edvardsson, 2000; Bergman and Klefsjö, 2003) (Oliver, 1996) quoted by Lilja and Wiklund, (2006). Still others use the emotion “delight” (e.g. Magnusson et al., 2003), which clearly changes the meaning as researchers have found that the drivers of satisfaction and the drivers of delight are not the same (Rust et al., 1994).

The scale in the proposed model has the maximum value in “delight” and the minimum value in “dissatisfaction”. We believe, in opposition to Kano, et al., (1984) that satisfaction is perceived within the zone of tolerance.

The horizontal axis issue

As noted, Kano et al. (1996) used the label “state of physical fulfilment” on the horizontal axis. Others refer to the horizontal axis of the Kano diagram as indicating how “fully functional” an

aspect of a product is (Berger et al., 1993), and more interestingly Bergman and Klefsjö (2003) use “degree of achievement” in terms of need fulfilment. (Lilja and Wiklund, 2006)

The proposed model is a quantitative approach based on the ideas of the theory of attractive quality. Therefore the label in the horizontal axis will be “performance” and the units in which are measured. For example performance (min) and the minutes plotted in the axis.

Integrating Taguchi ideas into the Kano model

Taguchi, (1987) considered four categories of quality characteristics: higher-the-better (e.g. computer's performance), lower-the-better (e.g. waiting time in a queue), nominal-is-best (e.g. time schedules) and asymmetric. In the next figure the Taguchi loss function is represented. Taguchi methods are claimed to have provided as much as 80 per cent of Japanese quality gains (Lofthouse, 1999).

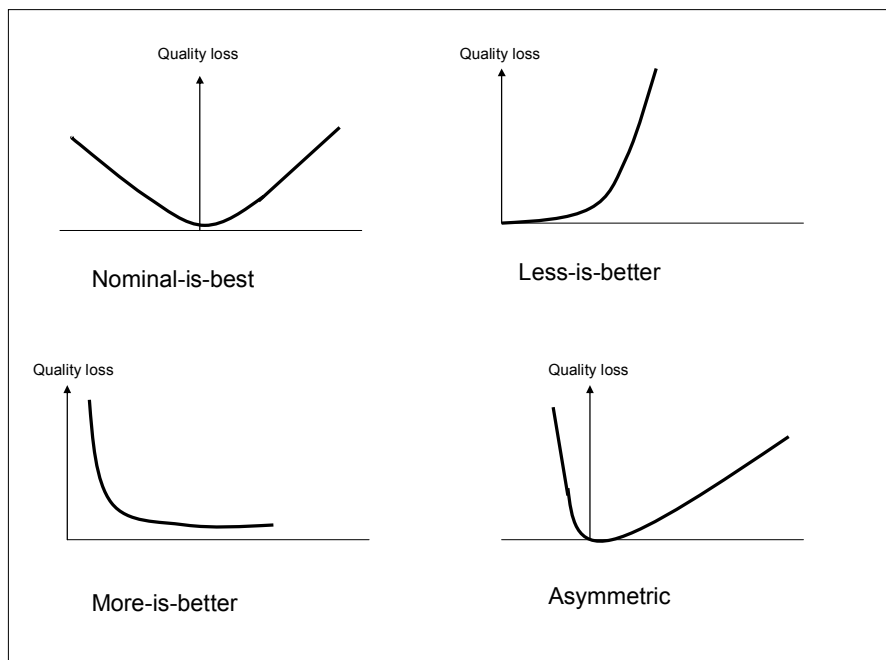


Figure 34- The four categories of quality attribute. Adapted from: (Phadke, 1989)

If we define the quality loss as the customer dissatisfaction, by inverting the Kano lines we can represent the quality loss function. The Kano model just analyzes the More-is-better attributes. It is important to include all the cases in the new model.

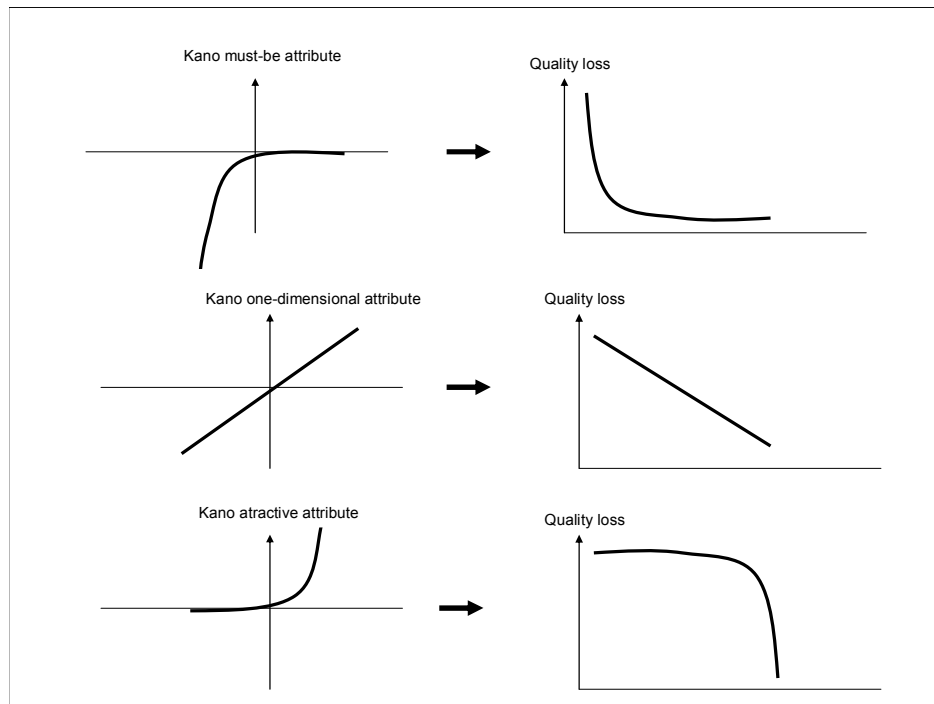


Figure 35- The Kano model just represents “more-is-better” attributes.

Kano model can be used just with “more-is-better” attributes

The original Kano model assumes that the designer knows if the attribute is more-is-better or less-is-better. There are some situations in which it can not be predicted beforehand. Pouliot, (1993) thought that the Kano classification table had some weakness. He modified it and suggested a new table with the reverses. Even he does not mention it in his article, what he was doing was introducing the “less-is-better” attributes in the Kano model.

		Dysfunctional				
		1.	2.	3.	4.	5.
		I like it	I expect it	I'm neutral	I can tolerate it	I dislike it
Functional	1. I like it	Q	A	A	A	O
	2. I expect it	R _A	Q	I	I	M
	3. I'm neutral	R _A	I	I	I	M
	4. I can tolerate it	R _A	I	I	Q	M
	5. I dislike it	R _O	R _M	R _M	R _M	Q

Requirement is:

A: Attractive O: One-dimensional
M: Must-be Q: Questionable
R: Reverse I: Indifferent

Table 4- Modified Kano evaluation table with reversals. Source: (Pouliot, 1993)

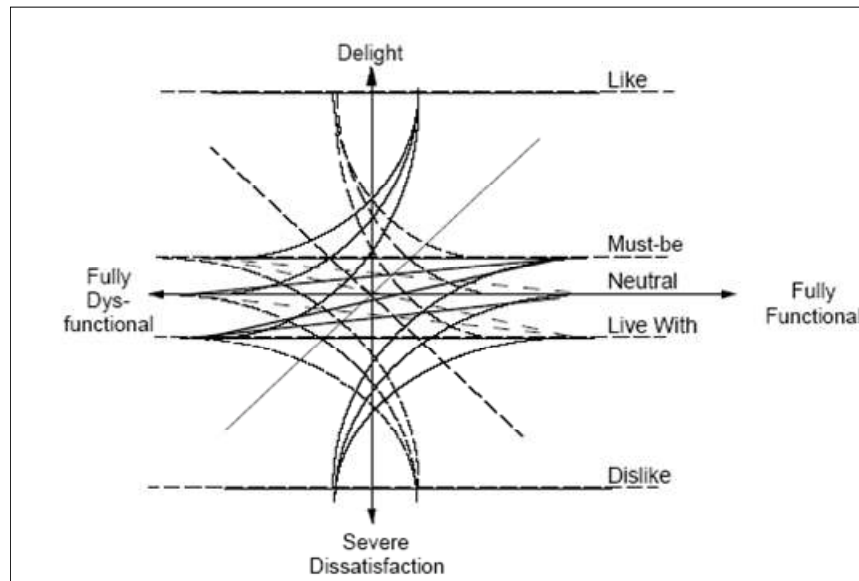


Figure 36- Lines taking into account “more-is better” and “less- is-better” situation. Source: (Pouliot, 1993)

What about nominal-is-best and asymmetric attributes?

Taguchi loss function theory is based on nominal-is-best attributes. The closer to the objective value the more satisfied the customer will be. The Kano model does not take into consideration the most common attributes, the “nominal-is-best” attributes. With Kano model the customer can be asked for good performance and bad performance. It is impossible to ask about the nominal point and the upper and lower deviation from this point. The new model that we developed overcomes this problem. For example if the bus departs later than the scheduled time you would be dissatisfied because you would arrive late. If the bus departs earlier than the scheduled time, you would be very dissatisfied because you are likely to miss the bus. If the bus departs on time you would not be satisfied or dissatisfied because you expect it to be like this. The new model allows this analysis and all the satisfaction-performance early/on-time/late can be represented in a single graphic.

Intuitive drawing of Kano lines

In the new model, we want to ask four different points of satisfaction in the same set of questions and represent them in one single graphic. For instance: how would you feel if the bus is 15, 10, 5 minutes late, on time and 5 minutes early. With this information the satisfaction-performance line could be represented. The problem is that with the Kano approach the maximum number of points asked is two.

We developed a new methodology to draw the Kano lines in an intuitive way; therefore the Kano classification table is not needed.

A3a: “I am neutral”, “I can tolerate it” and “It must-be in that way”, do not lead to increase or decrease of satisfaction. For example if the customer is asked “how would you feel if the bus is 0-5 minutes late?” and he answers “I can tolerate it” we will represent it as an horizontal line. Between 0-5 minutes late the customer will not have changes in the satisfaction level.

A3b: “I like it” and “I dislike” lead to an increase or a decrease of satisfaction. For example if the customer is asked: “How would you feel if the bus is 5-20 minutes late?” and he answers “I dislike it” we will represent it as an decreasing slope starting in 5 min and “I can tolerate it” and finishing in the dissatisfaction line.

Following these assumptions we can draw all the Kano classification table in an intuitive way. Note that we introduce the reverses in the table.

Dysfunctional Functional	I like it	It must be in that way	I'm neutral	I can tolerate it	I dislike it
I like it					
	Q	A	A	A	O
It must be in that way	Ar	I	I	I	M
I'm neutral	A	I	I	I	M
I can tolerate it	Ar	I	I	I	M
I dislike it	Or	Mr	Mr	Mr	Q

Figure 37- Intuitive classification of the Kano categories also considering the “less-is-better” situations

Note that the ZOT is between the “must-be” and the “I can tolerate” line. Within this zone the customers do not feel the variation, therefore even if they have a linear slope they are classified as indifferent. There are three different attractive classifications and three different reversal attractive classifications. The same with must-be.

Assumption 1 and 2 are used when one range is asked, for example, 5-10 min. The assumption 3 is used when one point is asked, for example 10 min.

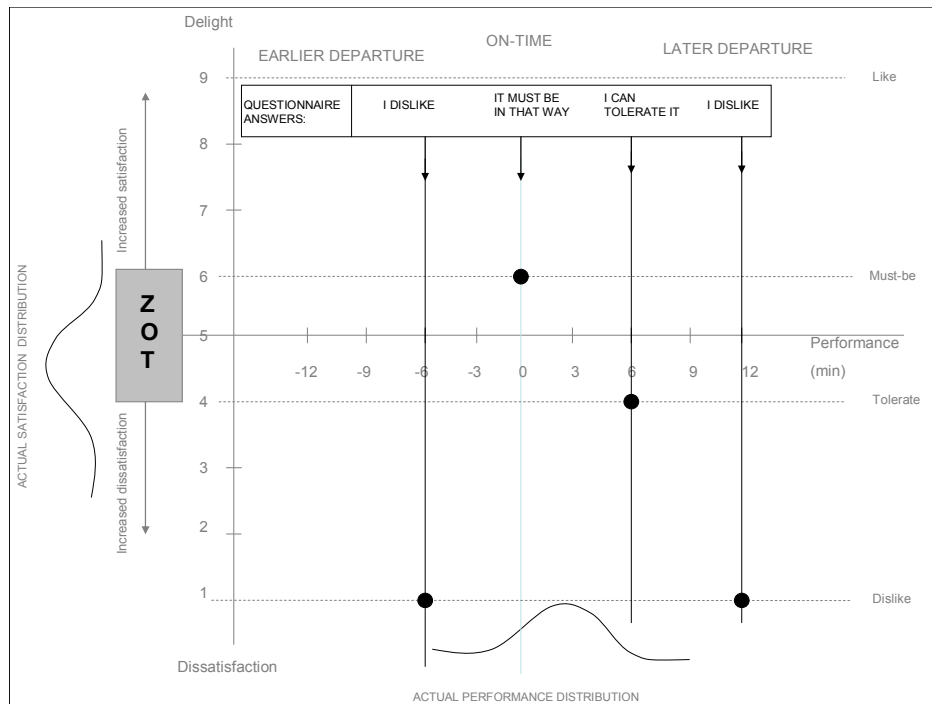
A3c: When one point is asked, for example if the bus is on time, how would you feel? The answer will be represented in a dot in the satisfaction line.

Following these assumptions, the approximate asymptotes and the dots of the curves can be drawn. Suppose that the customers are asked how would they feel if the bus departs six minutes before the scheduled time, on time, six minutes after and twelve minutes after and they answer the following:

If the bus DEPARTS 6 minutes BEFORE the scheduled time, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☒ I dislike it
If the bus DEPARTS ON-TIME , how would you feel?	☐ I like it ☒ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it
If the bus DEPARTS 6 minutes AFTER the scheduled time, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☒ I can tolerate it ☐ I dislike it
If the bus DEPARTS 12 minutes AFTER the scheduled time, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☒ I dislike it

Figure 38- Example of questions asking for the bus departure comparing with the scheduled time

With the questionnaire answers, the satisfaction in the different situations can be represented in the graphic.



After this the shape of the curve can be drawn. It is a simple way to represent the satisfaction-performance curves and gives the possibility of asking several satisfaction points

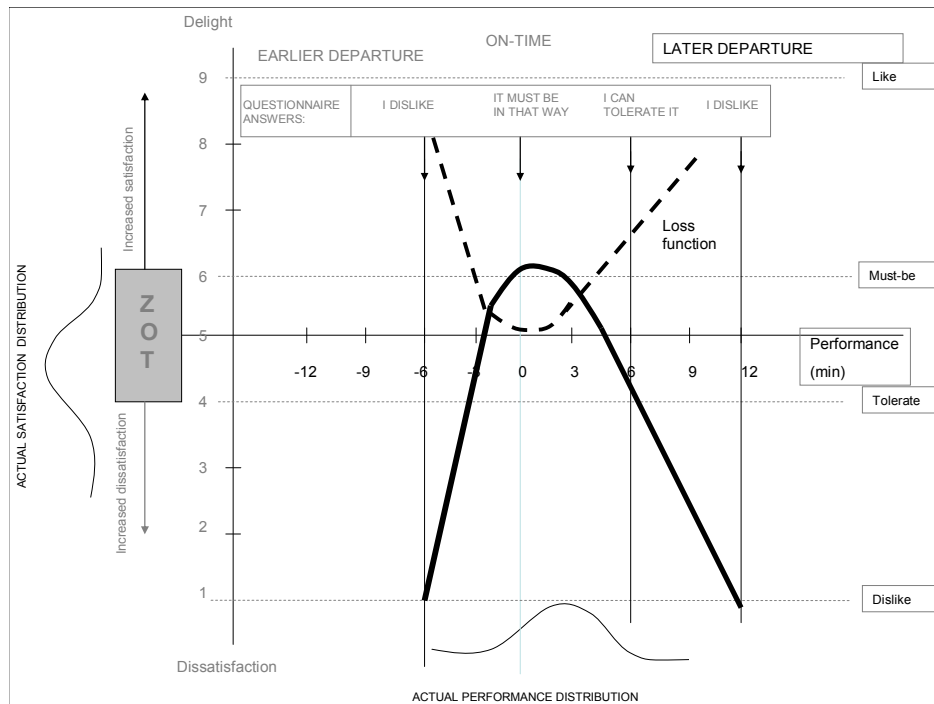


Figure 40- Linking the dots we obtain the satisfaction-performance curve

We have the satisfaction-performance qualitative shape.

Wording of the Kano questionnaire

In this section we analyze the original Kano wording and the wording presented in the special issue fall 1993 of the Center for Quality Management Journal. We disagree with some ideas and we present our alternative wording. According to Pouliot, (1993) the order of the five answers to the pairs of questions seems odd to many people.

1. I like it that way.
2. It must be that way.
3. I am neutral.
4. I can live with it that way.
5. I dislike it that way.

The question more frequently posed is: Why is “*I like It that way*” a stronger statement of satisfaction than “*It must be that way*”? (Pouliot, 1993) They propose the following alternative:

1. I enjoy it that way.
2. It is a basic necessity or I expect it that way
3. I am neutral
4. I dislike it, but I can live with it anyway
5. I dislike it, and I can't accept it.

Some Kano surveys have used this wording. However, while this alternative wording clarifies the difference between “*I like it*” and “*it must be*” (Pouliot, 1993) but from my point of view is quite long wording.

After several different wording alternatives, is presented other set of wordings from a participant in a session of the Center for Quality of Management Journal (name unknown)

1. I like it
2. I expect it
3. I’m neutral
4. I can tolerate it
5. I dislike it

According to the authors, this wording appears to distinguish between “*like*” and “*must be*” (“*expect*”) without becoming too extravagant (“*enjoy*”). We think that “*expect*” can be confusing. For example, some years ago I had orthodnocy. I had to go to the dentist once a month and he made me wait at least one hour every time. I was very dissatisfied with this bad scheduling. If I would have been asked: *If the dentist made you wait half hour how would you feel?* I can answer I dislike it but I can also answer I expect it because he always makes me wait more than half hour. If we change the wording to “*It must be in that way*” I would never answer “*It must be that way*”. Other issue that we observe it that the numbers before the wording could be confusing so we change them for a circle.

We disagree with Berguer, (1993), that “*it must be in that way*” is a stronger satisfaction statement than “*I like it*”. We think that “*I like it*” is close to delight and “*It must be in that way*” is within satisfaction. “*I like it*” is a stronger adjective for satisfaction. Normally the customers tend to classify the important attributes as a must-be. Hence “*It must be in that way*” is stronger in attribute importance classification than “*I like it*”. In the Kano questionnaire we want to know the customer satisfaction or dissatisfaction, not the importance. We also think that “*I can tolerate it*” is more clear than the original Kano wording “*I can live with it that way*” (too extravagant). Our final wording is the following:

- ☐ I like it
- ☐ It must be in that way
- ☐ I’m neutral
- ☐ I can tolerate it
- ☐ I dislike it

We think that this wording is easy to read, clear and can not lead to confusions.

The Kano model does not measure the attribute importance- The trade-off importance model

The objective was to find one model to know the relative importance of the attributes. As discussed in section I we did not find any model to analyze in an effective way the relative importance of the attributes. We decided to construct a new model for this purpose.

The basic idea of the new Importance Trade-Off model is that when explicit trade-offs between elements of the customer service mix are taken into account, different components of relatively importance emerge (Wetzels et al., 1995). The importance trade-off model is rather easy to answer and the output is the relatively importance of the attributes. It overcomes the “*everything is important*” problem because the customers are asked to select the best combination among a trade-off. The output of the model is a value of importance between 0 and 10. See appendix for further details in the model construction and analysis.

Example: I think that the attribute 1 with the value X2 and the attribute 2 with the value Z2 would be the best combination.					
Attribute 1	X1	X2	X3	X4	X5
	O	X	O	O	O
Attribute 2	Z1	Z2	Z3	Z4	Z5

Figure 41- The new model: trade-off importance. It is rather easy to answer and has good results.

MODEL OUTPUT

Finally, set specification limits!

The ZOT in the vertical axis mark the border between acceptable service, dissatisfying and delighting service. By translating this border to the horizontal axis (actual performance) we are translating the subjective quality defined by Shewart, (1931) to the objective quality. The ZOT can be draw and we obtain the specification limits!

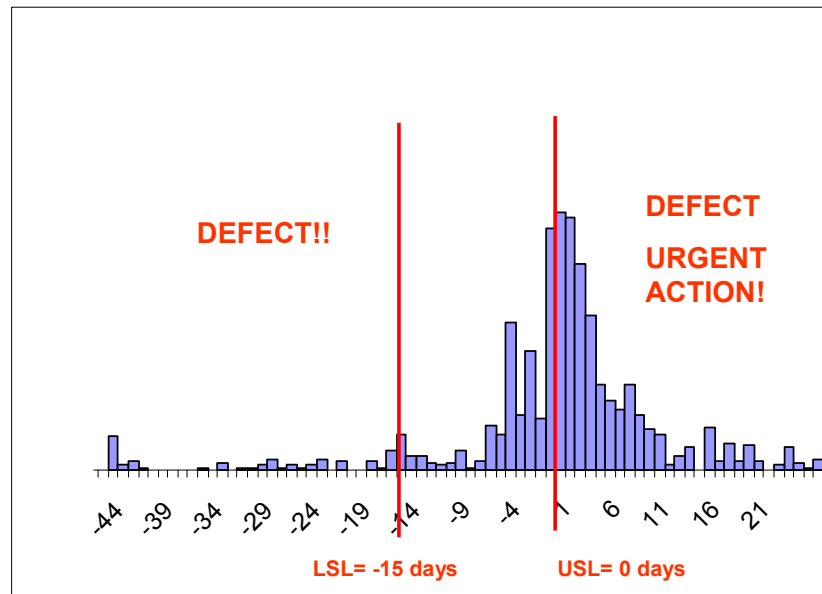


Figure 43- Capability analysis

Improvement directions

As we pointed out in previous section, the Kano model classifies but does not specify the improvement directions. Although the IPA model of quality attributes is a simple structure, it can provide much useful information about a company's quality performance. More than a strict strategy model, we think that it is a good visual classification to know the actual position of the attributes. We will introduce the importance information from the Trade-Off Importance model and the perceived performance from the SERVQUAL modified.

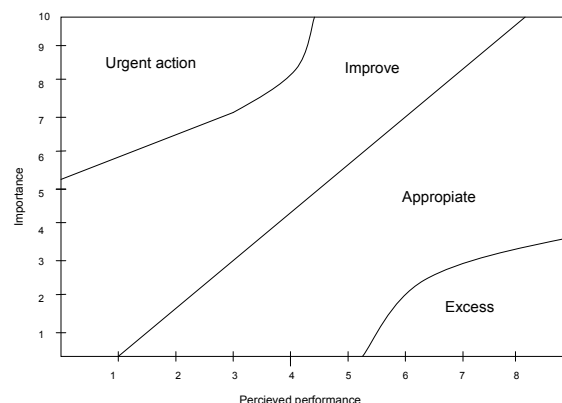


Figure 44- Importance Performance Analysis (IPA)

With the information from the interviews, historical data, the satisfaction curves, the loss function and the IPA it is important to do an analysis and conclusions. The methodology is rather

systematic, this step is the one that gives freedom and creativity to the practitioners, we believe that just looking to all the information in the final graphic a lot of conclusions can be drawn. This is the main strength of the proposed model.

CONCLUSION

While research on customer satisfaction has been focused on quality service measurement, in the main publications, no effort has been made to set the specification limits in services. In this section such a model was developed.

All the approaches in the literature have problems working separately. We definitely agree with the ideas of the theory of attractive quality but we find that it is a purely qualitative approach. The importance of treating expectations as distributions and the need for understanding the effect of performance variability on customers' evaluation have been pinpointed by several authors as critical issues to be addressed in the service quality research (Puga-Leal and Pereira, 2007).

We constructed a new model having as a basis the theory of attractive quality ideas. With the integration of SERVQUAL and the trade-off importance model into the Kano model, we obtain a more quantitative Kano model. The main strength, of the new model is that all the information is compacted in a single graphic. The presented approach is easy and quick to answer for the customers, visual and easy to analyze and it serves not only to set the specification limits but also to assess actual quality service and improvement directions.

SECTION IV

Model application in the Service Division, Siemens Industrial Turbomachinery AB- Analysis, results and recommendations

Cronemyr, (2007) pointed out the necessity of understanding process variation and monitor the process performance not just with the traditional bar charts of Key Performance Indicators (KPI) but also with SPC control charts. Currently the KPI's are calculated with specification limits without analyzing the customer needs. Some process values are classified as a bad performance indicator but the customers may be satisfied and some other values are classified as good performance but the customers may be dissatisfied. The model presented in section III will help the organization to set the specification limits for the calculation of the KPI's according to the real customer needs. The objectives of this section are: (i) to present the company background; (ii) to show the analysis, results, recommendations and Specification Limits from the model for each KPI;

A research was made within the company with Black Belt projects, KPI's, external audits, company business cases, previous master theses in the company, literature and internal data.

INTRODUCTION

Cronemyr, 2007 developed a model for process management that is being used in SIT AB. According to this approach (see figure) the first step is mapping processes (middle), second run Six Sigma projects (bottom) and third go for the process control (top). Phase 1 and 2 are running successfully, a thesis work was developed to define whether the workers agree with the process development approach.

Currently the Phase 3 is not used in the proper way. The control phase is performed with a bar chart with the monthly average value. The decisions are made according to the difference of this value and one target value without taking into account the normal variation and setting the target values by guessing. In an other Master Thesis the process control charts were developed. The aim of this Master thesis is to close the control loop setting the target values based on the real customer needs. The setting up of the specification limits based on the real customer needs will allow the company to use a SPC control loop in the “Six Sigma way”.

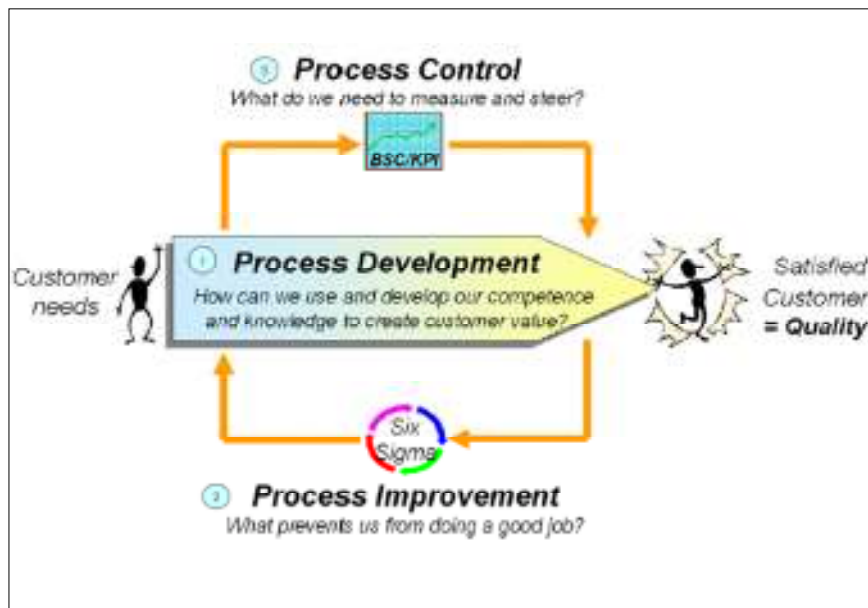


Figure 45- Process Management at Siemens Source: (Cronemyr, 2007)

The problem of the bar charts

This section is from Cronemyr, (2007); he explains the problems of the bar charts and the importance of understanding variation in the service division.

It is not easy to teach an old dog new tricks. Of course this is just a saying. I do not insinuate that there are dogs in the Service Division, but there are managers who are used to look at KPI bar charts in Excel. On several occasions I pointed out that it was not right to react to individual values in a bar chart. One should instead look for 'normal variation', a concept that is not easy to understand. That was the reason I employed two students to do their diploma work at the Service Division in Finspång. The title was 'Implementing statistical process control at a Service Division' (Ellström and Sellgren, 2007).

So what exactly is the problem with bar charts? While they are easy to understand, they do not tell a whole lot about the process. This is illustrated by a fictitious example (because of company confidentiality, real data have been manipulated for this example). shows the ratio of fictitious deliveries made on time per month during a year. The average (of monthly averages) is 77% deliveries made on time. Is it good enough? No. In July 2006 the ratio was well over the target of 90%. Was there any justification for cakes to everybody? But now there seems to be downward trend in the last month. What to do?

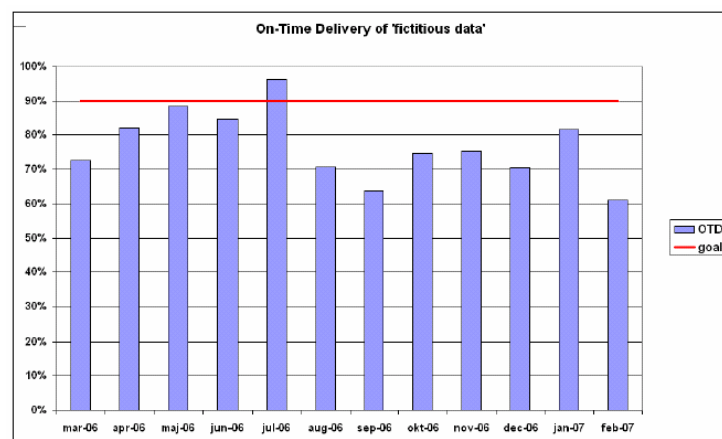


Figure 46- An Excel bar chart showing the ratio of fictitious on-time deliveries.

The control charts, using the same basic idea, but showing lead time instead of on-time-delivery ratios, are developed and interpreted by a Black Belt. The control chart (Xbar) for sub groups of 14 samples show very few alarms. These should be investigated. As can be seen, even though there is a small increase in lead-time the last month, the process is stable. Unfortunately there was no justification for cakes in July 2006. The 'normal variation' in the process is far too large.

MODEL IMPLEMENTATION

Questionnaire design

A well-designed survey is an important and effective way in which we can better understand what people are thinking and doing (Janes, 2001). The integrated approaches are normally time-consuming to answer and analyze, for example Yang, (2003); Tan and Pawitra, (2001). The most

important constraint was that the questionnaire must take maximum 5 minutes to answer. It has three parts:

- *Kano modified* questions was for obtaining the satisfaction-performance lines, i.e. to link the subjective quality with the objective quality.
- *SERVQUAL modified*; the purpose was to measure internal and external customers' perceived performance and to measure their minimum service level.
- *Trade-Off Importance model* was designed to extract the customer relative importance of the different attributes.

After analyzing all the service division KPI's we decided the most important and representative, three KPI's for internal customers and other three KPI's for external customers. The questions were carefully structured to capture customers' perceptions and predictions and the level of importance of the attributes of the services in the service division. The questionnaire was designed, using the model presented in section 2 and the roadmap in the annex I. The main rules we followed in the design are:

- Easy to do.
- Omit all the questions with an obvious answer.
- The time spent to do the questionnaire can not be greater than five minutes.
- As few questions as possible.
- Represent realistic results with a low noise level.
- The questions avoid the "everything is important" or "everything is ok" problem
- The questions directions as clear and short as possible
- For a quicker understanding the key words must be highlighted with capital bold letters
- Units in the scales (points, months, working days, calendar days...)
- Good layout and presentation
- Include spaces for comments
- Order the questions from the easier and quicker to answer and understand to the most difficult one.
- Include a short personalized covering letter
- Include terms definitions

Questionnaire verification

Verification is a procedure to ensure that the questionnaire is built according to specifications and to eliminate errors in the structure, naming, length, type of questions and to receive general suggestions. After several discussions with my advisor, Peter, we selected three black belts to verify the questionnaire. The external questionnaire verification was carried out by Lars Akelin, the Market Manager.

Sample

We changed some details in the questionnaire according to the black belts suggestions. We selected the following internal stakeholders to do the questionnaire:

Service Division Manager
Market Manager
Market Manager
Market Manager
Logistics Manager
Purchase Manager
Financial Controlling Manager
Financial Controlling Manager

The Market Manager selected eight reliable customers' different companies and countries. The target was to have a high response rate.

Customer	Position
Pepco Energy Services	Plant Manager
City of Vernon	Plant Manager
Växjö Energi	Underhållschef
Shell Raffinaderier	Underhållschef
Lunds Energi	Underhållschef
Edp	Maintenance Manager
EniGas	Maintenance Manager
TITAN	

Data collection

It is very important to have a high return rate. For example, (Yang, 2003), made a survey with an integrated approach, 1400 persons where mailed randomly, resulting in 150 valid questionnaires. In this situation the questionnaire is useless because it does not represent the general opinion. Only the customers that are very satisfied or dissatisfied have answered.

I spoke personally with all the internal stakeholders, I explained to them the purpose of the study and I asked them to answer the questionnaire with a short personalized covering letter. I did not give more details when I handed in the questionnaire to have more objective results. This face-to-face contact and their sensibility to customer satisfaction and continuous improvement was the key for a 100% return rate.

I mailed the external customers with the attached questionnaire. I called them to ensure that they received correctly the survey.

ANALYSIS AND RESULTS

INTERNAL STAKEHOLDERS PROCESSES

CUSTOMER OVERDUE INVOICES

The customer overdue invoices are the number of invoices paid beyond agreed terms. It is clear that the bulk of effort devoted to managing debtors and creditors throughout the economy is essentially wasted. These administrative processes add no value (Rafuse, 1996).

Country	1989	1994
France	28	24
Germany	18	19
Italy	34	37
Ireland	34	34
Sweden	18	18
UK	51	49

Table 5- Late payment business debt (average number of days beyond agreed terms) Note that Sweden is the country with less overdue days in average. Adapted from: Rafuse, (1996)

The Black Belt project (Johansson, 2004) made significant improvements in the KPI: The short term target was 30% overdue invoices and 10% was considered best in class. In 2007 the short term target has been reached by far, 15% in average.

In the internal business case “*DSO reduction program*”, a benchmarking was made. The competitors have fewer days in average overdue invoices. This demonstrates that there is an opportunity to release significant working capital as we operate in the same market with the same customers.

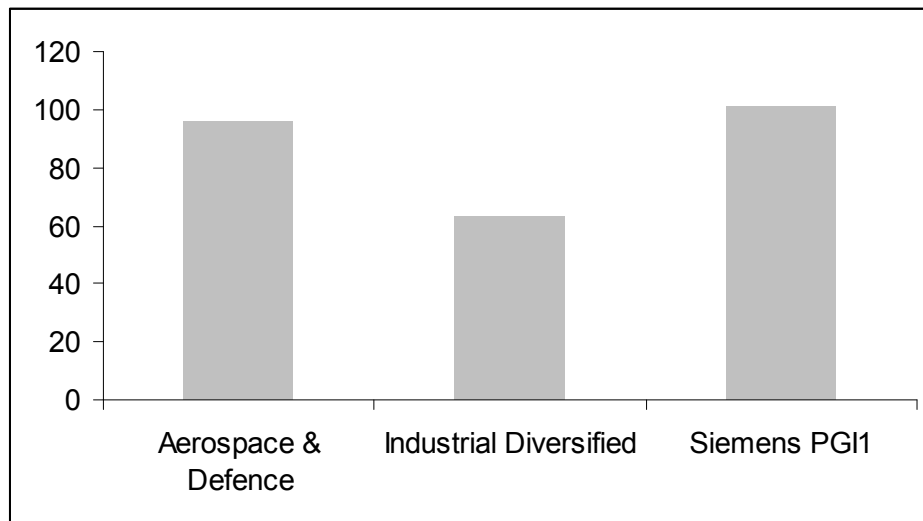


Figure 47- Benchmarking, note that the competitors have fewer days in average overdue invoices. Based on total sales 03/04 / Avg debtors 03/04

Analysis

The KPI measures the percentage of overdue invoices (number/number) and the value of these invoices. The main problem with the overdue invoices is the hidden credit given to the customers. Therefore it is interesting to see the distribution of the days that the invoice is overdue. Ten days of overdue can be considered a minor problem and one year overdue is a real problem.

It is difficult to find the historical data of the days that the invoices are overdue in the moment of payment because they disappear from the system. Ellström and Sellgren, (2007), gathered this data. We analyzed it, counting as not overdue the invoices paid in less than three days late because is the time that the system spend in detecting the payment.

The distribution is asymmetrical, with outliers that increase the mean. For example, monitoring my on-time arrival to work every month, I arrive normally on-time, but if I am ill 3 days (outlayers), it will count as 8 hours late every day. The results will show that I am 48 minutes late in average. This result does not represent the reality. When looking to the median, the result is that I arrive -1 minutes late.

In the overdue invoices is the same case, we must look to the median. 25% of the invoices considered overdue are paid within 5 days, 50% within 17 days and 75% within 48 days. Currently the KPI is considering that all the invoices that paid late (even one day) are a bad performance indicator. In the internal business case “*DSO reduction program*”, the importance of monitoring the distribution of the days late is highlighted. We see that the majority of the overdue invoices are paid in a few days. Is it a big problem to receive the payment in a few days? Do the internal stakeholders think that some days overdue is acceptable? Maybe it would be interesting to set other specification limit different than 0 days for this measurement. If the customer pays

before the agreed date how would the internal customers feel? Is it a good think? Or maybe not.

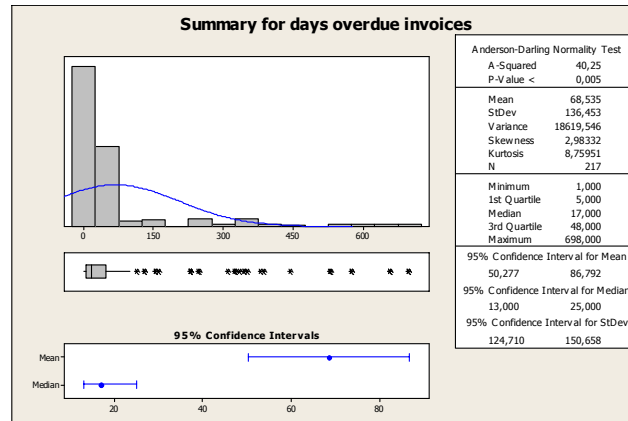


Figure 48- Note that the majority of the invoices that are overdue are paid a few days late

Results

The model does not just analyze the Voice of the Customer. Also the Voice of the Data and the Voice of the experience.

Voice of the Customer

The internal stakeholders think that it is the less important attribute (3/10). The bold line is the performance-satisfaction line. In the model, the internal stakeholders consider that the zone of tolerance is between 0 days and 10 days overdue. If the invoice is paid on time or before the agreed date, it leads to increased satisfaction and if it is paid later than 10 days it leads to increased dissatisfaction. The loss function (dashed line) is lineal, the longer the more expensive the credit.

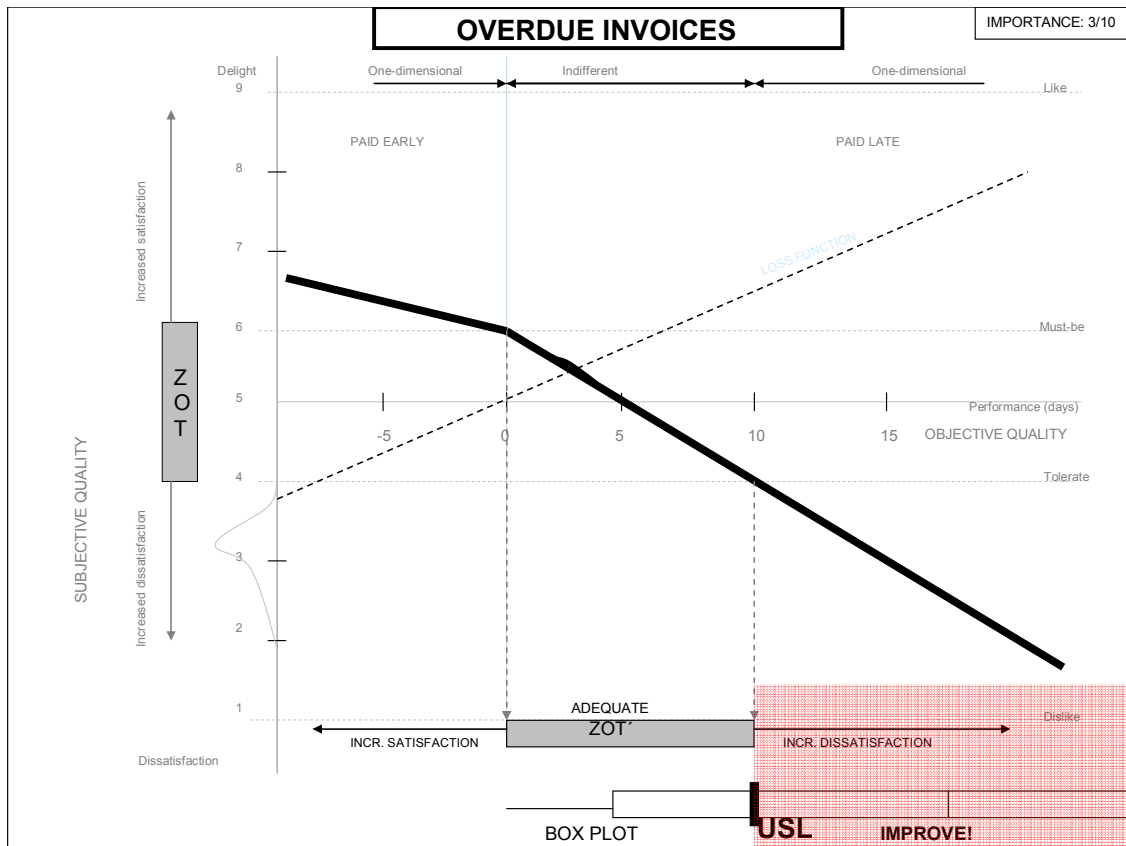


Figure 49- Model final graphic

Voice of the historical Data

The historical data is represented in the lower part of the graphic. Besides, we have done an analysis of the cost that cause the overdue invoices. The invoices that are paid in more than 70 days represent 20 percent of the invoices and cause 80 percent of the hidden credit. It is called the 80:20 rule, introduced by the Italian engineer Vilfredo Pareto in the late nineteen century. Pareto constructed histograms of the distribution of wealth in Italy and concluded that 80 percent of the country's wealth was owned by 20 percent of the nation's population. This trend was later found representative of the distribution of other data populations. The 80:20 rule, or a variation known as ABC analysis that uses an 80:15:5 classification rule, is now routinely used in many fields of study (Knights, 2001). This rule is used for example in inventory management, 20 percent of the items represent 80 percent of the income. These are classified as A and prioritised.

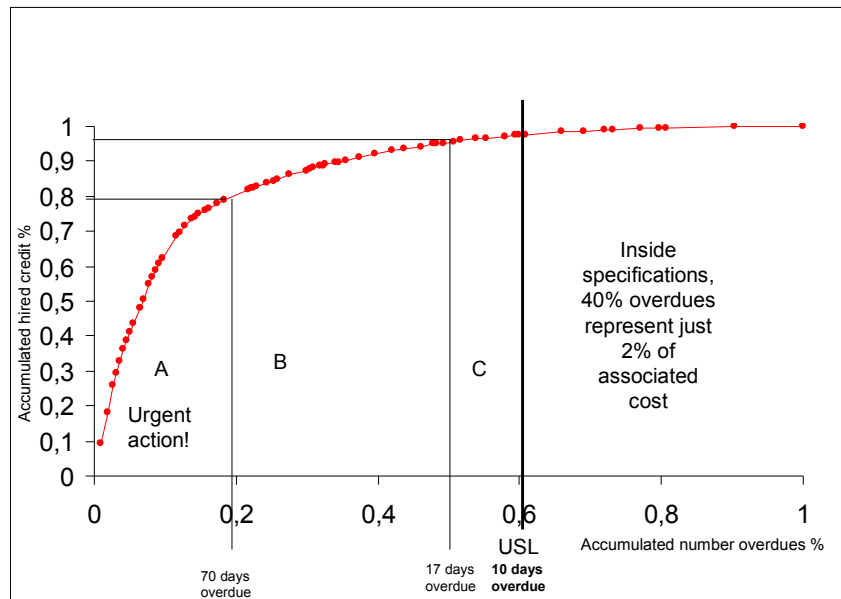


Figure 50- ABC analysis hidden credit versus number of invoices

In the graphic above, observe the ABC classification of the hidden credit depending on the number of overdue invoices. Note that in this case the rule is exactly right. 80 percent of the associated cost is caused by 20 percent of the overdue invoices. These invoices are paid 70 days late and are classified as A, urgent action is needed. By eliminating these classified a savings of more than 1,3 million SEK in hidden credit a year are calculated.

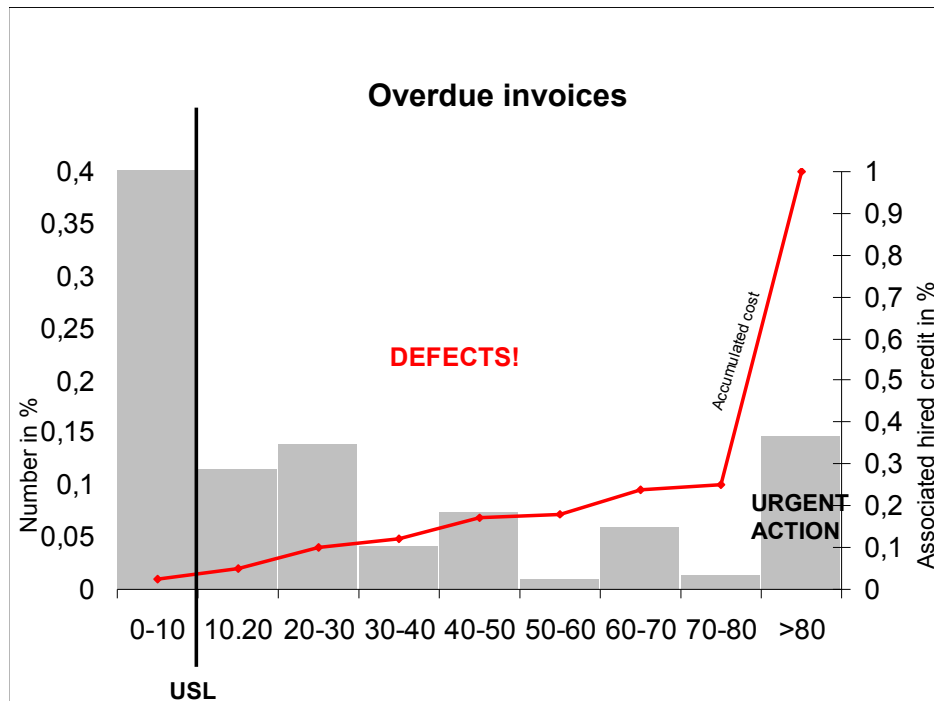


Figure 51- Histogram of the number of overdue invoices and the associated cost (line)

Voice of the experience

The model is really easy to understand, it allows to introduce the Voice of the Experience. We had a meeting with the Financial Controller Managers and the author of the Six Sigma project, they agreed with the results in the model and the proposal of monitoring the monthly hidden credit. We propose to move the specification limit to the border of the zone of tolerance, USL=10 days.

AN OVERDUE PAID AFTER 10 DAYS WILL BE CONSIDERED AS A DEFECT.

The majority of the overdues are paid few days late. 40% of the invoices are paid within 10 days and represent 2% of the hidden credit. They have a big repercussion in the KPI but low in the real problem, the hidden credit.

Capability analysis

In the following graphic is represented the histogram together with the associated loss function.. Note that the loss function represent the associated cost of one overdue invoice in function of the days paid late.

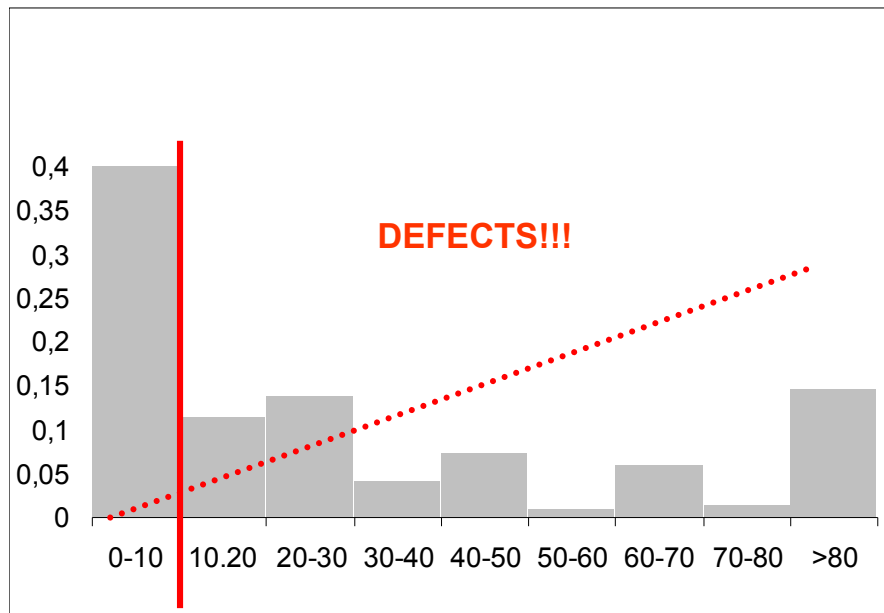


Figure 52- Capability analysis and loss function

Improvement proposals

The real problem for the organization is the hidden credit. The KPI is measuring the number of invoices that are paid late and their value. We have seen that the invoices that are paid in less than 10 days represent just the 2 percent of the hidden credit. We propose to change the KPI, invoices paid in more than 10 days. (See figure)

The KPI is measuring the value of the invoices. We propose to change it for the monthly hidden credit. It is more realistic because the real problem is monitored. The money that the organization is losing due to the overdue invoices.

$$\text{Hidden credit} = \text{Value invoice} * \text{number of days late} * \text{credit in days}$$

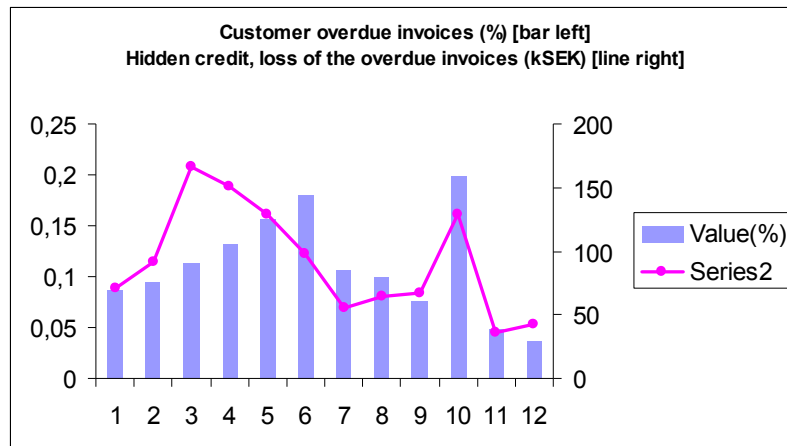


Figure 53- Proposed KPI, overdues paid in more than 10 days and the associated hidden credit

The main cause of the overdue invoices is the Slow payer. In the Cause-and-effect diagram, one of the causes is that there are not penalties if the customer is delayed. We propose to introduce in the contract penalties that the customers must pay if they pay the invoices late. For example a credit rates a day that the overdue is late. With this, the associated hidden credit would be paid by the customers.

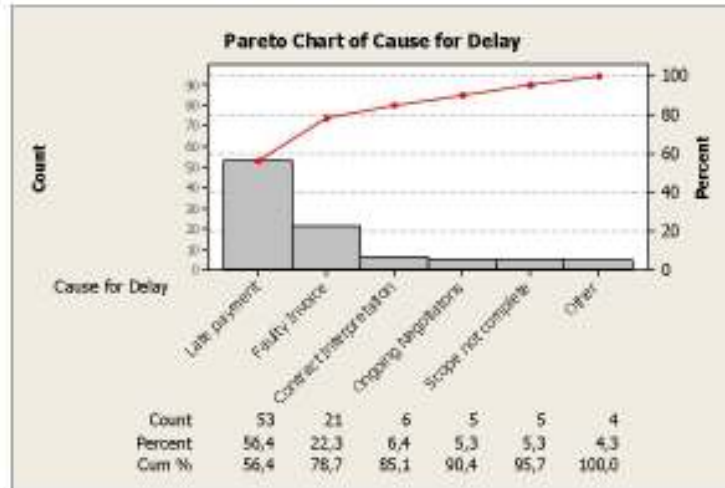


Figure 54- Late payment is the main cause. Source: (Johansson, 2004)

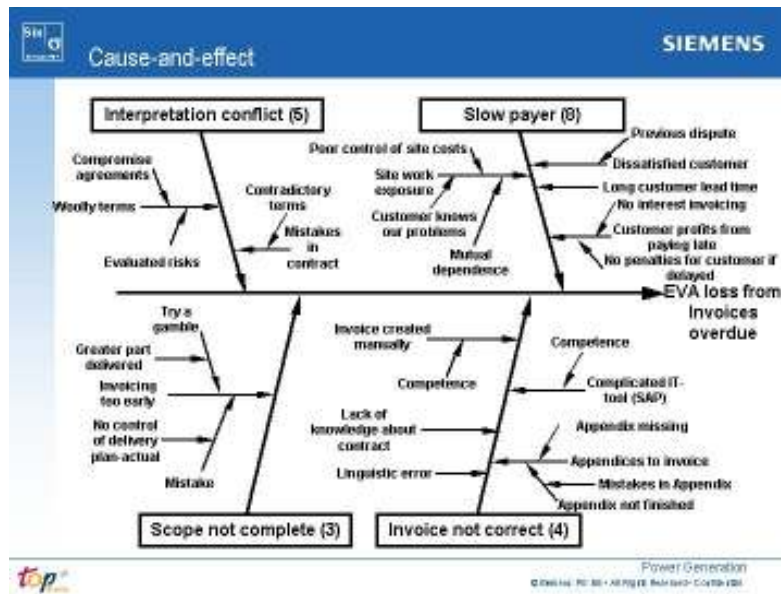


Figure 55- Cause-and-effect analysis Source: (Johansson, 2004)

INVOICES SENT LATE

One invoice is sent late when it is sent to the customer after the agreed date. The external customers welcome the late invoicing process due to the resulting hidden credit given them (Andersson, 2006). According to the six sigma project, Andersson, (2006) the amount of invoices is always high the last month of each quarter, and the amount of credit invoices is low. The next month the amount of credit invoices is high. This is probably the result of the quarter report being focused on quantity (no of invoices), rather than quality (no of invoices actually paid).

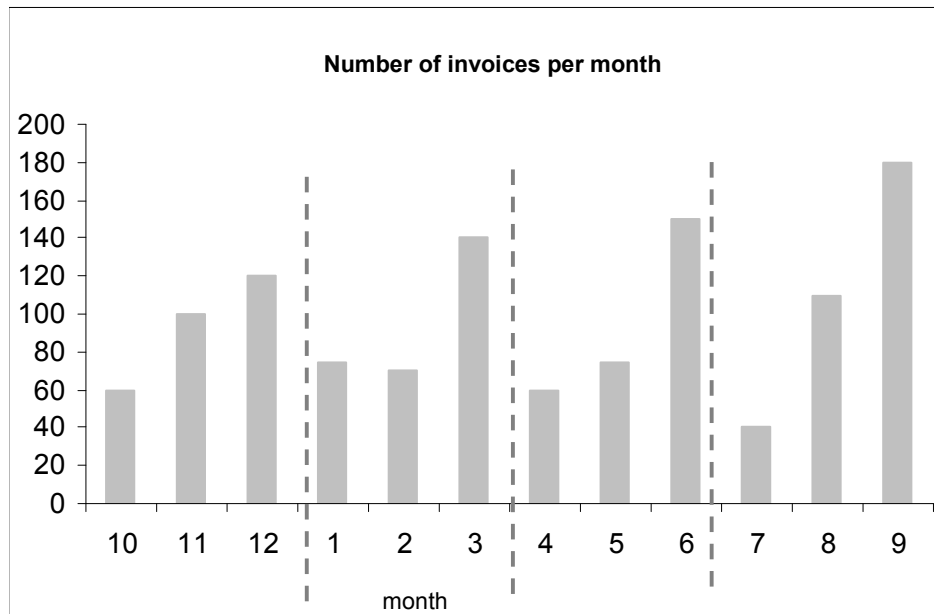


Figure 56- Note that the number of created invoices is higher in the end of each quarter. Source: (Andersson, 2006)

Analysis

The KPI, as the overdue invoices KPI, measures the number of delayed invoices and the value of these invoices. The number of days that the invoice is sent late to the customer is difficult to obtain because there is not historical data. We could gather some data handwritten with the date that the invoice was actually sent. We have a sample of 27 invoices sent late from the end of 2007.

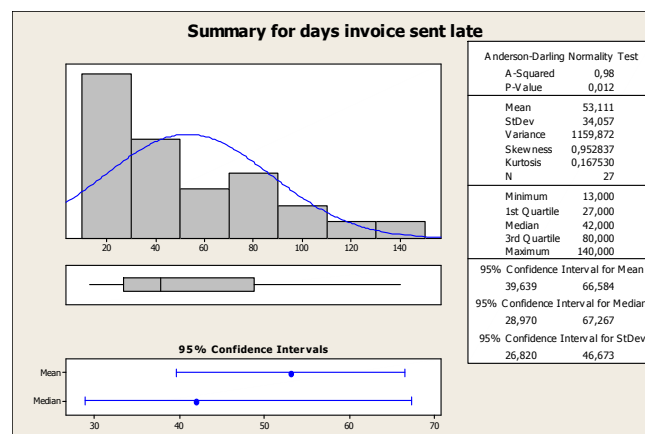


Figure 57- Distribution only showing the late invoices

In the box plot, 25% of the invoices that are late are sent within 27 days. 50% within 42 and 75% within 80 days. The minimum is 13 days. If the specification limit is 0 days or 10 days there will not be any difference since the minimum is 13 days. Is it right the traditional view of the KPI (0 days specification limit)? Is it acceptable 20 days late? What about if the invoice is sent before the intended date? How would the internal customer feel in this situation?

Results

Voice of the Customer

It is the second most important KPI (3/10). The internal stakeholders consider that every deviation from the invoice plan is a defect in the process. It is a must be requirement, a bad performance will lead to increased dissatisfaction, however a good performance will not lead to internal stakeholder delight.

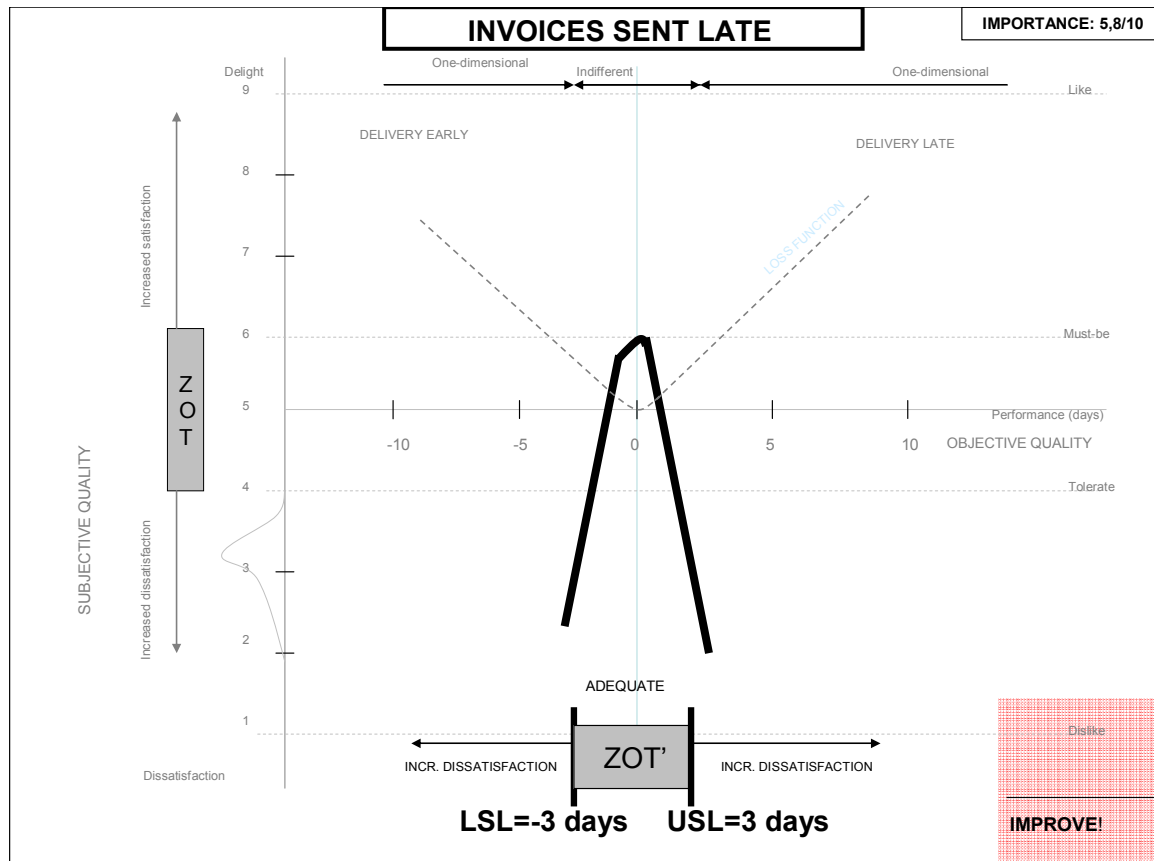


Figure 58- Model final graphic- Invoices sent late

Voice of the Historical Data

In the lower part of the graphic is represented the Box-Plot of late invoices.

Voice of the Experience

We had a meeting with the Financial Controlling Managers and the author of the Six Sigma project. We decided to consider as bad performance every deviation for the invoice plan. USL=3 days and LSL=-3 days. In this case, no SPC monitoring is needed. The KPI that indicates the number of invoices that do not follow the invoice plan is good. The objective must be to strictly follow the invoice plan.

EVERY DEVIATION FROM THE INVOICE PLAN IS CONSIDERED AS A DEFECT

The invoice plan is not followed. It is a big and important problem. Every deviation for the invoice plan must be considered a bad performance. It is the easier KPI to improve.

Improvement proposals

It is the easiest KPI to improve. According to Andersson, (2006) the main cause is that the invoice plan is not followed. A new process was defined where deviation from invoicing plan is monitored by business administration department and reported to Managers every month (a new KPI). This has lead to significant improvements.

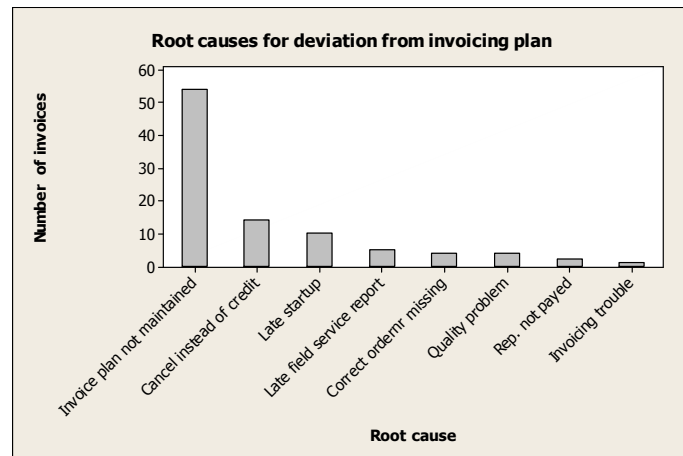


Figure 59- Root cause analysis Source: (Andersson, 2006)

The KPI, as the overdue invoices KPI, measures the number of delayed invoices and the value of these invoices. As we pointed out in overdue invoices, the problem with the invoices sent late is the hidden credit given to the customers. We propose to monitor in both, overdue invoices and invoices sent late the monthly hidden credit. This measurement would be really useful because it would allow a direct comparison of the waste that the bad performance is causing.

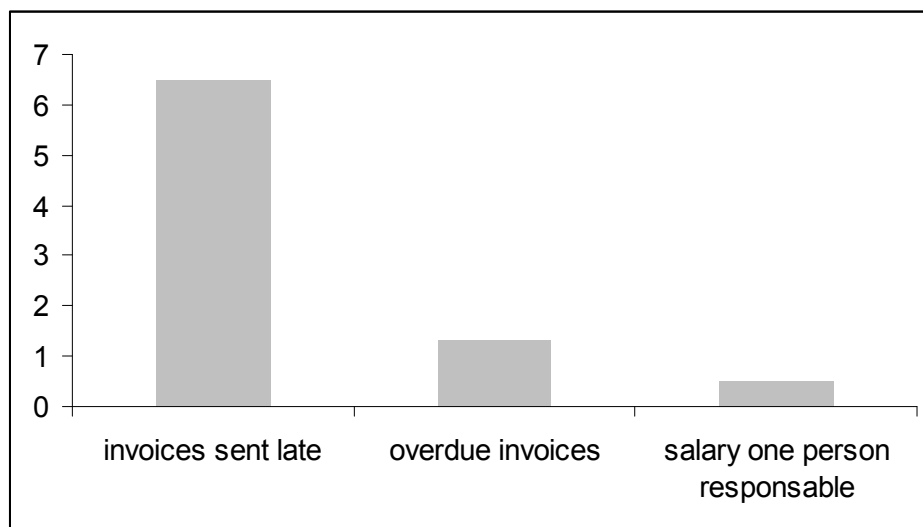


Figure 60- We recommend to employ one person responsible for the invoices sent late

SUPPLIER ON-TIME DELIVERY

A supplier's on-time delivery (OTD) metric is a comparison of the promise date and the actual date the material or part is received. According to the Black Belt project "Improve on time delivery on purchased parts" (Carlsson, 2006) On time delivery is essential to meet customer requirements. Before the Black Belt project the on time delivery was (60%-70%), the goal was 90% of OTD. In order to be able to deliver to the external customers on time, the availability of the purchased items is a necessity (Carlsson, 2006).

Analysis

We plotted the histogram and box-plot for OTD with data from April 2007 to October 2007, with the difference between the actual date and the confirmed date in subgroups of 25.

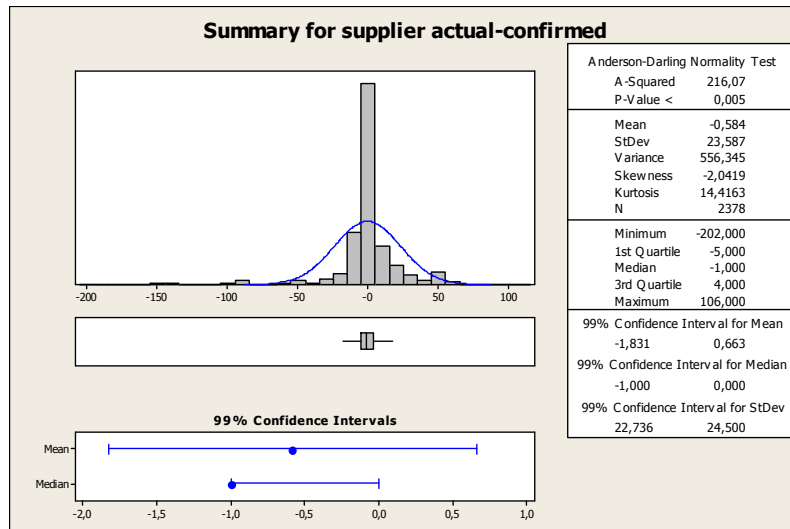


Figure 61- Sample 2378 on-time delivery from supplier from April 2007 to October 2007

It is obvious that late delivery will lead to customer dissatisfaction. But is the limit in zero days? Or the customers can tolerate a few days late? What about the delivery before the requested date. Receiving one spare part one month before the requested may not be a good thing. How does the customer feel in this situation? Is it needed a lower specification limit?

Results

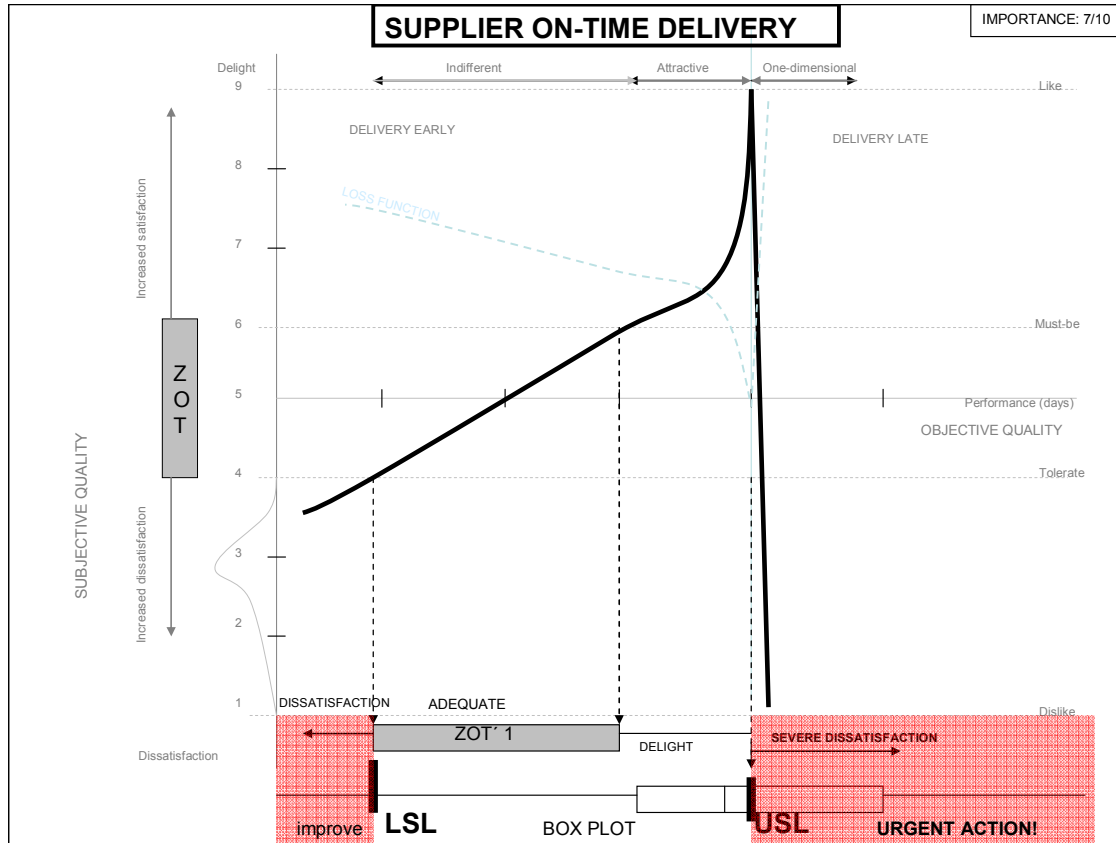


Figure 62- Model final graphic

Voice of the Customer

Supplier OTD is ranked the most important attribute, (7/10). In the following graphic we can observe that the graphic has three different phases.

Severe dissatisfaction area

When the delivery is late, the Kano classification is one-dimensional and the result is a severe dissatisfaction. All the respondents answer that they would be dissatisfied with the delivery 5 days late and 7 out of 9 respondents consider no admissible the delivery one day late. This, the fact that this attribute is by far ranked the most important and the dramatically increase of the associated cost in the lost function when the delivery is late make the necessity of setting the Upper Specification Limit (USL) in 0 days late.

Attractive area:

The majority of the respondents consider that the delivery less than five days before is an attractive. It means that if the delivery is 5 days before, the internal stakeholders are not dissatisfied but if the delivery is for example 1 day before or on-time they are delighted. The associated cost in the loss function is minimal and it is the best area to situate the distribution of the real performance.

Indifferent are:

Between 5 and 15 days before, the customers would not notice the difference; they are in the Zone of Tolerance (ZOT).

Dissatisfaction area:

If the delivery is before than 15 days early the internal stakeholders start to be dissatisfied, the associated cost of warehouse and the hired credit paying before the confirmed date make this area a dissatisfaction area. The Lower Specification Limit is set in 15 days before. Currently this LSL is not taken into account. One delivery 2 months before the confirmed date is considered a good performance.

Voice of the historical data

In the following graphic, is represented the percentage of deliveries falling in the different zones. Note that 40% of the deliveries are in the severe dissatisfaction area.

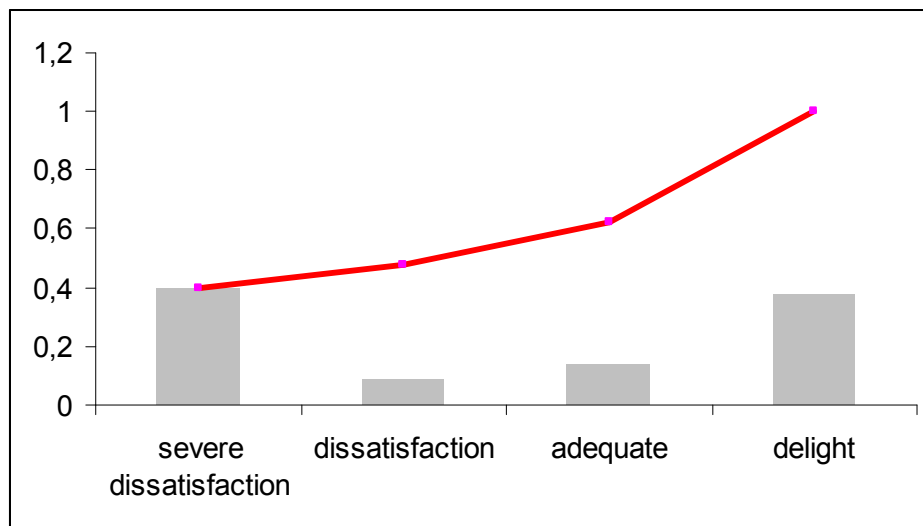


Figure 63- Actual satisfaction

Voice of the Experience

We had a meeting with the Logistics Manager and the Purchase Manager. The priority for the organization is to reduce the late deliveries. The deliveries before the confirmed date are

sometimes caused by the economic order quantity (EOQ) ordering. A limit is set 15 days before of the confirmed date because of the associated cost.

Capability analysis

With the specification limits set by the customers, the real process sigma of the process can be calculated. To perform the capability analysis we assume that the distribution is normal. In services, where the human is the main player it is difficult to have normal distributions with 95% confidence level, it is needed to transform the data. Instead, we propose to calculate the percentage of conformance with specifications. There are tables to transform the yield into a sigma value.

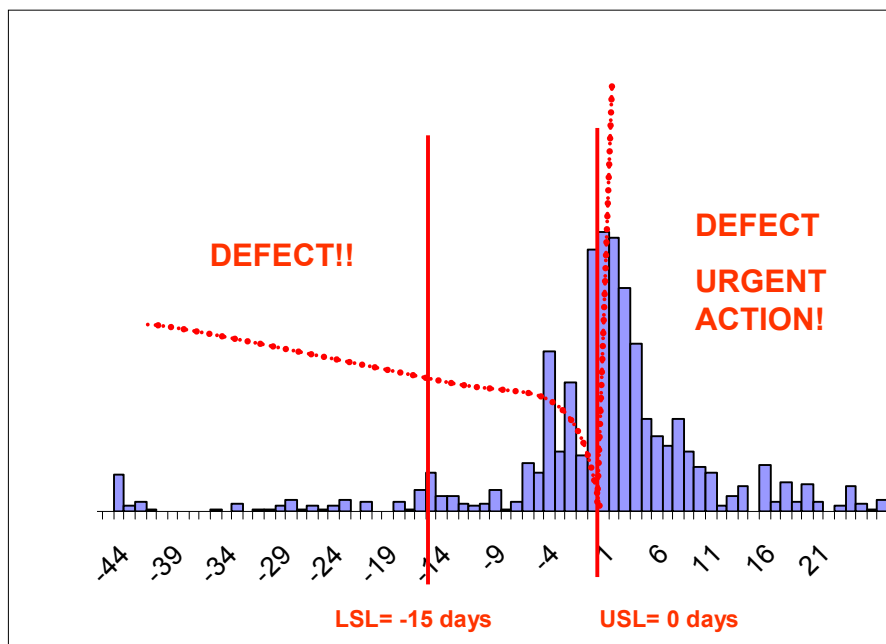


Figure 64- Capability analysis

Improvement proposals - Distribution centering

The organization has the target of on-time delivery. In average the deliveries are 0 days late. The target is reached. But, is it a good thing?

No. Every process has a natural variation. When going to the airport, I always try to be there 20 minutes before the check in closes. 20 minutes before is my target value because I understand that there is a variation. In this case the distribution is centered in 0 days late, the variation of the process makes 40 percent of the deliveries fall in the severe dissatisfaction area, 40 percent of the time the organization is losing the plane.

The satisfaction-performance curves together with the associated asymmetric loss function are very useful to understand that it is not just important to meet the specification limits. It is also important to center the distribution in the right area to maximize the customer satisfaction and minimize the associated cost. Changing the target value from 0 to -10, with the same process variation, the company can increase dramatically customer satisfaction and competitiveness, while the associated cost is reduced.

This way of thinking was first introduced by Genichi Taguchi in the 1950s and early 1960s. Taguchi methods are claimed to have provided as much as 80 per cent of Japanese quality gains (Lofthouse, 1999).

ONE DELIVERY EARLIER THAN 20 DAYS IS A DEFECT

ONE DELIVERY AFTER THE CONFIRMED DATE IS A DEFECT

It is not admissible any day late. USL=0 days. It is the most important KPI. The target value must be changed to 10 days earlier. The associated warehouse cost and hidden credit paying before make the necessity to set LSL= -20 days.

According to (Carlsson, 2006) the main causes were no margin for internal transport, late request and supplier not reliable. In this black belt project is highlighted the need of measurements executed on a monthly basis to secure that the process remains stable and according to objectives.

There is a big opportunity to improve this important process. The two main causes, no margin for internal transport and late request, are caused by the organization. It is needed urgent action in these two root causes. The third cause is supplier not reliable. It is more difficult to improve because it depends on the supplier. We suggest asking the suppliers for quality standards such SPC monitoring of the deliveries.

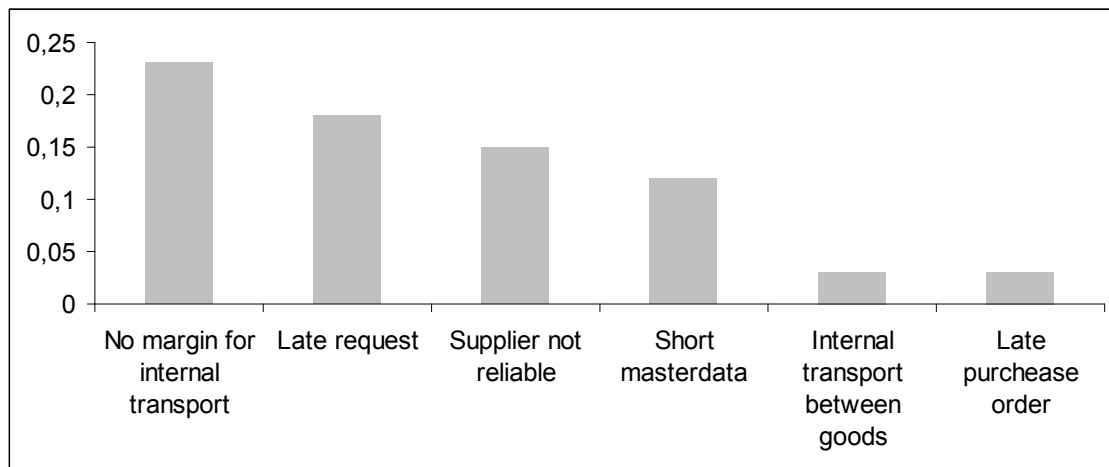


Figure 65- Root cause analysis. Source: (Carlsson, 2006)

In the following graphic, observe that the supplier B has a low variation in the delivery time, some times is one day before, sometimes one later. It is a good performance. The supplier A has a huge variation; they can deliver 1 year before requested or on time. The customer B has less than 50% of On-time delivery and the customer A 100%. Which one would you prefer? This example shows the necessity of controlling the process monitoring the deviation from confirmed date with SPC.

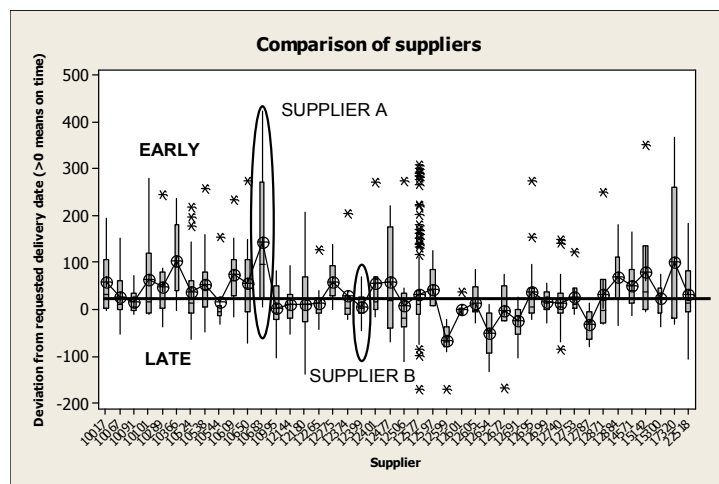


Figure 66- Comparison of different suppliers. Supplier A is always on time but with a huge variation; Supplier B has a low variation but sometimes is late. Source: (Carlsson, 2006)

EXTERNAL CUSTOMER PROCESSES

SPAREPART QUOTATION

It is the time between the customer spare part quotation request until the customer receives the quotation. There is an ongoing project for improving the quotation time.

Analysis

25% of the spare part quotations are delivered the same day as requested, 50% within 4 days and 75% within 10 days. The actual specification limit is USL=10 days. How do the customers feel if the sparepart quotation is ready in 10 days? Is it needed a new specification limit? And in 2 days? Does this increase of performance increase their satisfaction or they are indifferent. If the spare part quotation is ready in 15 days, how would they feel? Can they tolerate it or they are dissatisfied.

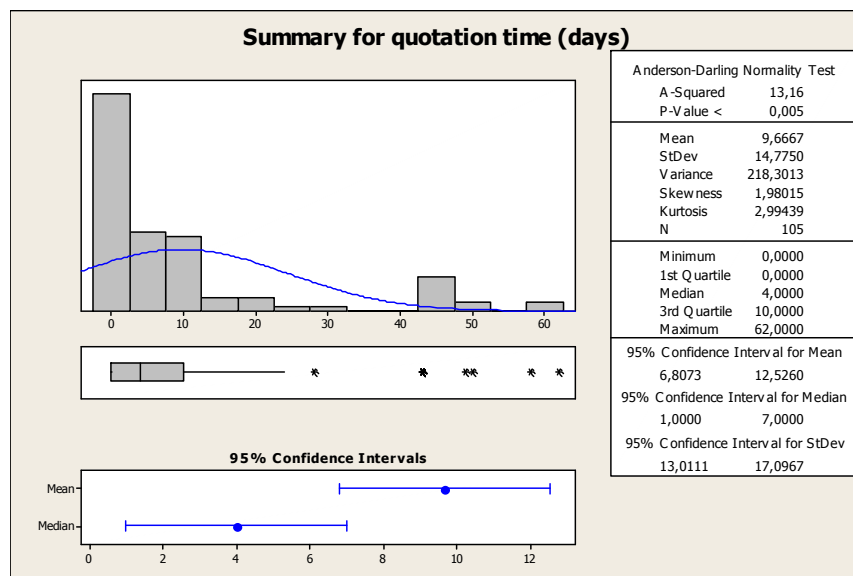


Figure 67- Quotation time april 2007 for gas turbines.

Results

Voice of the Customer

Quotation time is the less important KPI. The zone of tolerance is situated between 7 and 15 days. Quotations done in less than 7 days lead to increase customer satisfaction and quotations done in more than 15 days lead to customer dissatisfaction. The zone of tolerance is wide, according to Johnston, (1999) the width of the expectation zone of tolerance is inversely proportional to the degree of involvement (importance).

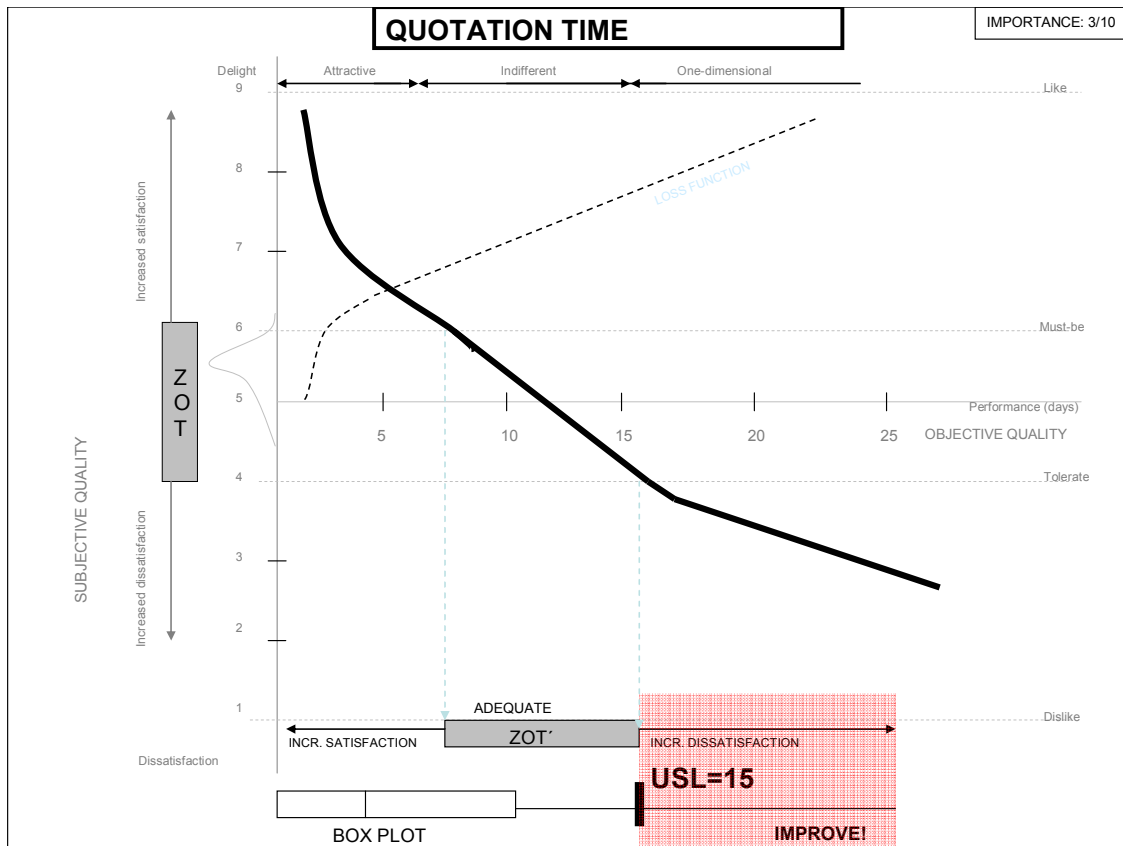


Figure 68- Model final graphic

Voice of the Data

50% of the quotations are done in less than 5 days (attractive area), 75% are done within 10 days. There are approximately just 15% outside specifications. All the respondents answer that this attribute meets or exceeds their desired service level. It can be due to the low importance and good performance of the company.

Voice of the Experience

We had a meeting with the Market Managers and the author of the Six Sigma project. We agreed to set the specification limit in 15 days and a target of 3 days.

A QUOTATION TIME DELIVERED IN MORE THAN 15 DAYS WILL BE CONSIDERED AS A DEFECT

It is the less important parameter and the one with better perceived performance

Capability analysis

In the following graphic is represented the histogram together with the associated loss function.

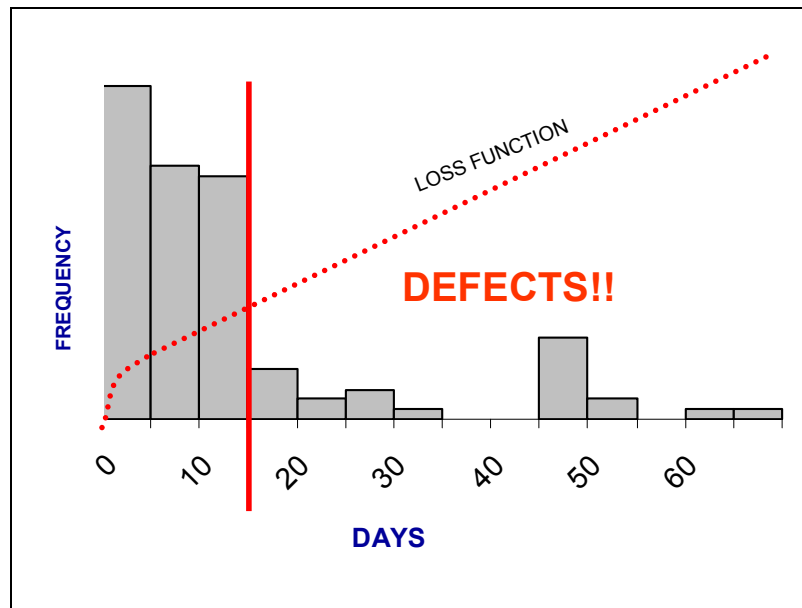


Figure 69- Capability analysis with the associated loss function

Improvement recommendations

This attribute is ranked by the customers as the less important and with better performance. Observe in the graphic above that the majority of the points fall into the attractive area (less than 7 days late), this make increase customer satisfaction. Some points fall in the dissatisfaction area. As it is the less important attribute only extreme actions will have an effect in customer dissatisfaction.

INSPECTION REPORT DELIVERY TIME

It is the time between the site job ends until the customer receives the inspection report. Complaints about late inspection reports have been made on several users conferences for gas turbine customers. According to one audit in December, 2004 the invoicing field service commissions can not be done before the inspection reports have been given to the customers. This leads to hidden credit. In the black belt project “Improve inspection reporting”, (Andersson, 2005) the VOC was analyzed. The process owner for the delivery process estimates that reports delivered within 4 weeks are requested. In the control phase the USL is set in 28 days.

Analysis

25% of the inspection reports are delivered within 18 days, 50% within 35 days and 75% within 82 days. In this case it is really interesting to set the specification limits according to the customer needs. Would they like if the report is in 1 month? When would they start to be dissatisfied with the delivery time? If the report is delivered in one week, how would they feel? Maybe they like it or maybe not because they have to pay the bill earlier than expected. In this case would be useful to set an USL but also a LSL.

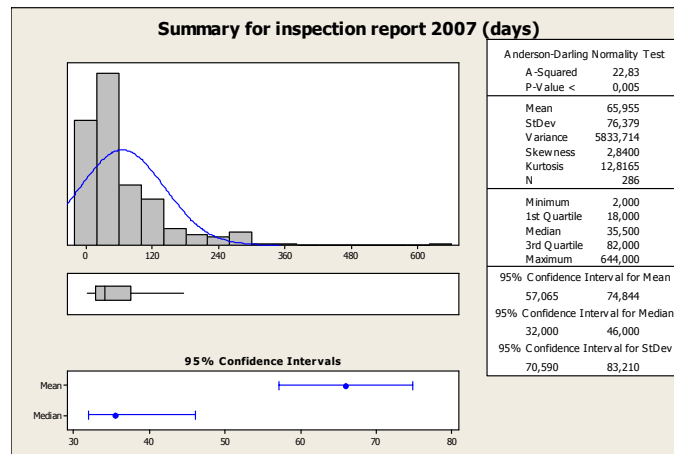


Figure 70- Inspection report delivery time. Sample 286 from 01/07 to 05/07

Results

Voice of the Customer

The customers think that this KPI is the second most important. The zone of tolerance is situated between 30 and 45 days. Inspection reports given in less than 30 days lead to customer satisfaction and in more than 45 days to customer dissatisfaction.

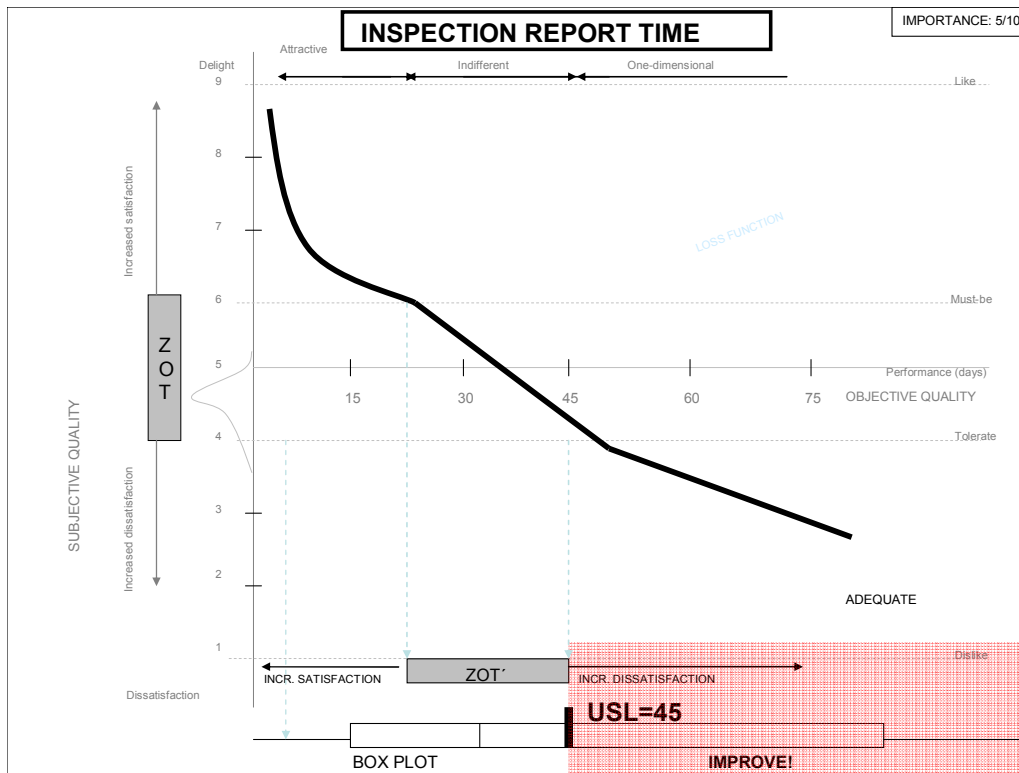


Figure 71- Model final graphic

Voice of the data

There are approximately 40% of points outside specifications. That is the reason why the customers are not satisfied with the performance. 6 out of 7 customers think that it does not reach their desired service level.

Voice of the experience

We had a meeting with the market managers and the author of the Six Sigma project. We agreed to set the specification limit in 45 days and a target value of 15 days.

Capability analysis

In the following graphic is represented the histogram together with the associated loss function.

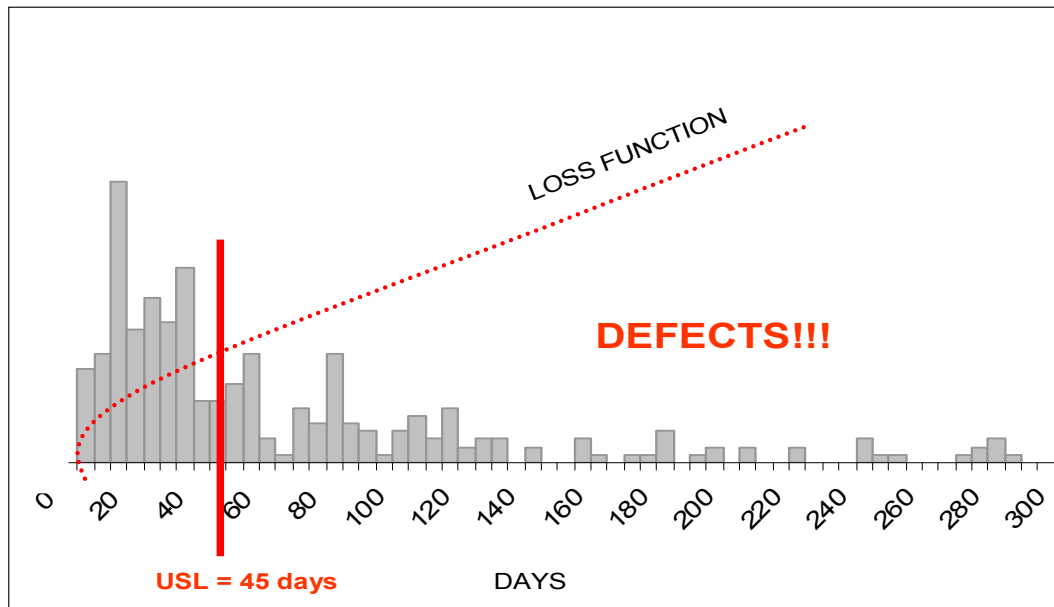


Figure 72- Capability analysis, inspection report

Improvement proposals

The perceived performance is a little bit lower than the desired service level. 35% of the points are outside specifications. It is needed a variation reduction.

**AN INSPECTION REPORT DELIVERED IN MORE THAN 45 DAYS WILL BE
CONSIDERED AS A DEFECT**

The main cause for the long inspection reporting times is the workload.

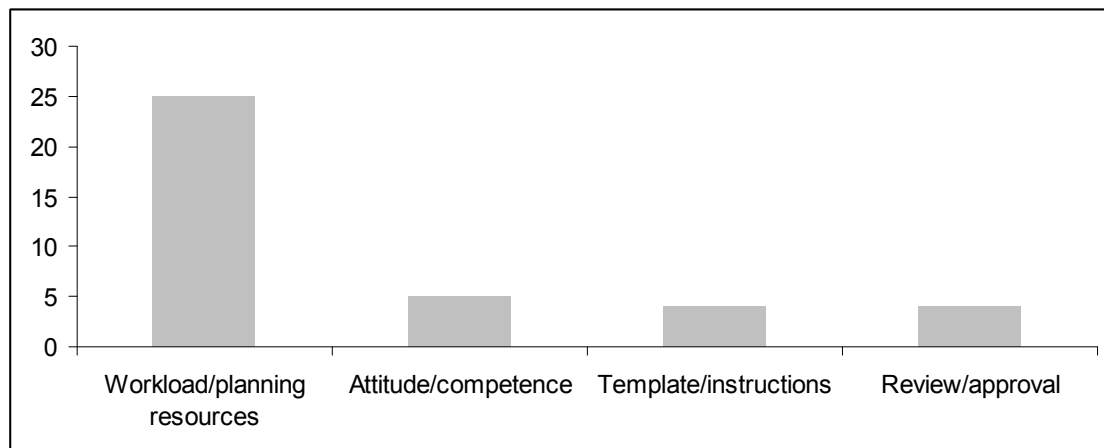


Figure 73- The workload and planning of resources is the main cause. Source: (Andersson, 2006)

ON TIME DELIVERY EXTERNAL

On-time delivery (OTD) external metric is a comparison of the promise date and the actual date the material or part is received by the external customer.

Analysis

50% of the deliveries are between on-time and 17 days early. The variation without considering extreme points and outliers is from 40 days early to 25 days late.

It is obvious that late delivery will lead to customer dissatisfaction. But is the limit in zero days? Or the customers can tolerate a few days late? What about the delivery before the requested date. Receiving one spare part one month before the requested may not be a good thing. How does the customer feel in this situation? Is it needed a lower specification limit? All these questions will be answered in the next chapter.

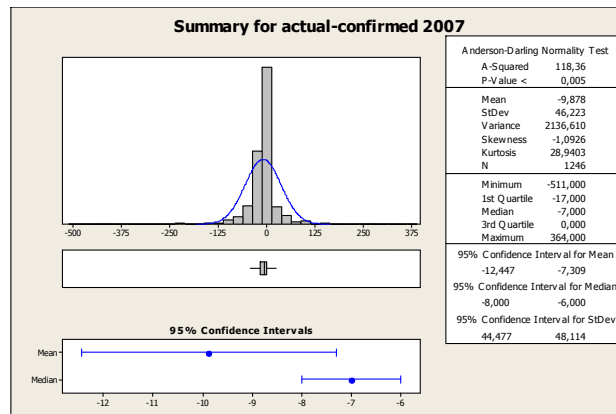


Figure 74-

Results

Voice of the Customer: The conditions are different depending if the service assignment is revision work or repair maintenance. When doing revision work the machine shall be ready for operation a predefined date. However when doing maintenance work, the machine should be running as soon as possible. In this section we will focus on maintenance work. The external stakeholders want the delivery as soon as possible. They prefer to receive the delivery before the confirmed date than ontime. If the delivery is late they can run into a lot of problems.

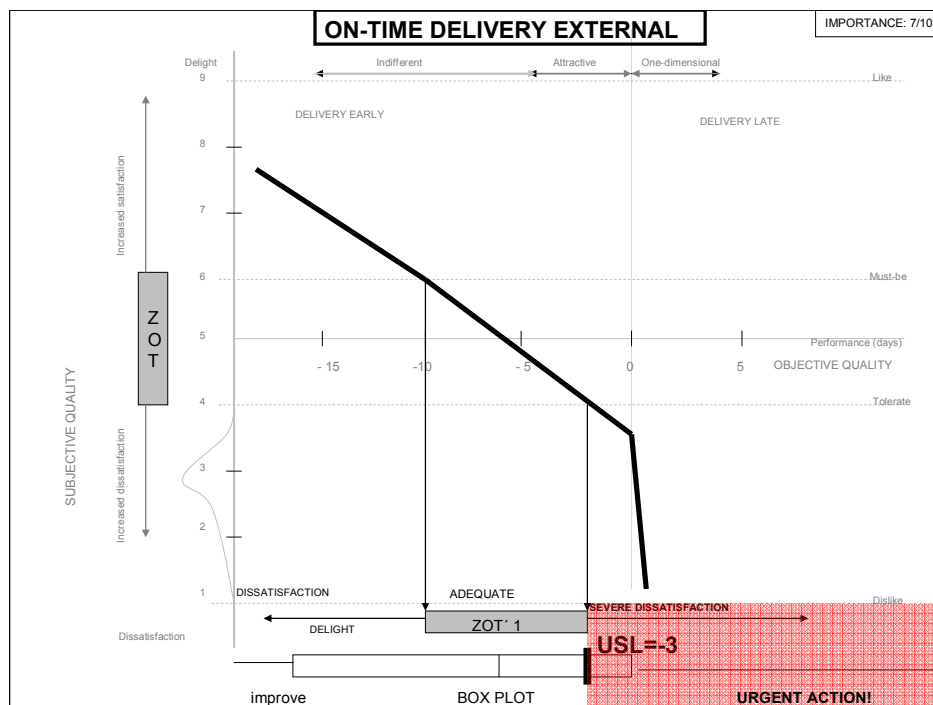


Figure 75- Proposed model

Voice of the data: The performance of this attribute is quite good. The distribution is centered 10 days before the confirmed date.

Voice of the Experience: We had a meeting with the Market managers. They agreed with the importance of this parameter for the customer and the fact that there must be always ongoing continuous improvement Six-Sigma projects. They suggested to start the implementation of the SPC monitoring with this process. Even if the customers prefer to have the delivery before confirmed date, is not reasonable to count as a bad performance a delivery on time. We agreed to set the specification limit in 0 days and the target value in 10 days early.

IN MAINTENANCE WORK THE CUSTOMERS WANT THE DELIVERY OF THE SPAREPARTS AS SOON AS POSSIBLE USL=0DAYS

It is by far the most important process, it is needed a continuous improvement

Capability analysis

In the following graphic is represented the histogram.

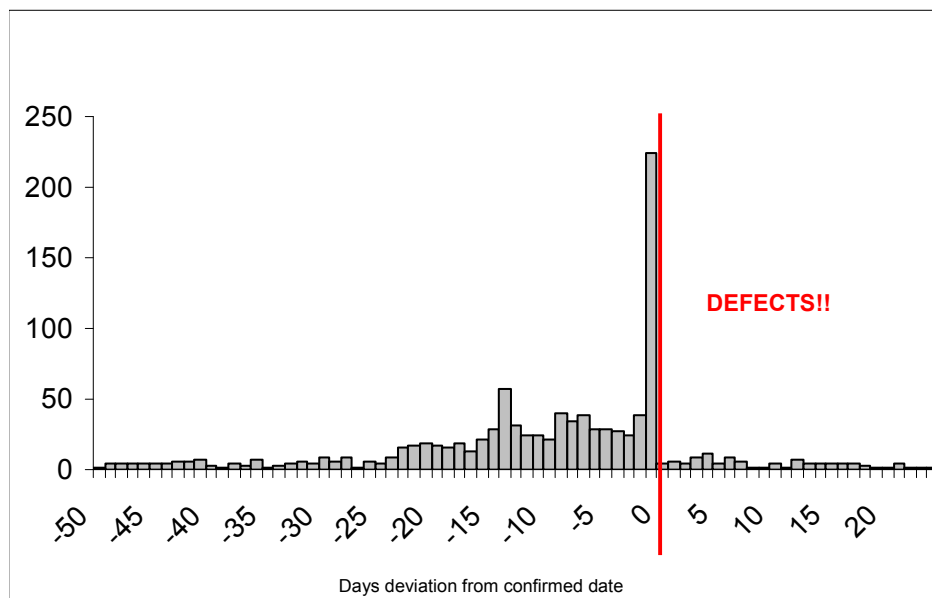


Figure 76- Days deviation from confirmed date in on-time delivery external

Improvement recommendations

According to the VOC analysis in the black belt project, (Carlsson, 2006) if the purchased parts for any reason are not available, it would be desirable for the customers to receive continuous information regarding late deliveries and changes from the purchasing department. Also, expediting and frequent follow-up is required. It is important separate the data between revision work or repair maintenance and perform a continuous SPC monitoring of this parameter.

This process is crucial for the competitiveness of the company. We will not explain the complete improvement recommendations because of company confidentiality.

STRATEGIC DIRECTIONS

IPA is a very simple, visual and useful tool. In the vertical axis is represented the attribute importance and in the horizontal axis the attribute perceived performance. The IPA has been used in two different graphics because the perception varies depending the internal stakeholders and external customers.

INTERNAL STAKEHOLDERS ANALYSIS

The overall perceived service level by the internal stakeholders is lower than the desired service level. It does not mean that is a bad performance, the opposite it reflects the continuous improvement way of thinking of the Service Division Managers. To enhance internal stakeholder satisfaction, improvement efforts must be targeted, in order of priority.

- 1- Supplier On-Time delivery (OTD) is ranked the most important attribute and the perceived performance is poor. Urgent action is needed.
- 2- Invoices sent late is quite important KPI, if an invoice is sent late, it has a hidden credit. Is the second parameter in which the efforts must be targeted.
- 3- Overdue invoices is ranked the parameter with lower performance. However it is the less important, it falls in the improve area, near to the appropriate area.

The improvements must move the dots in the direction to the arrows to reach the desired service level. Even if supplier OTD reach the desired service level, as it is the most important attribute must be continuous improved.

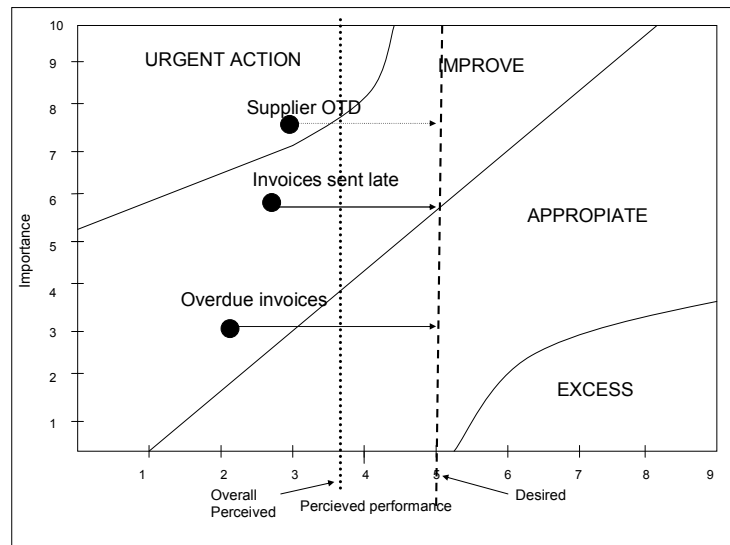


Figure 77- Internal Stakeholder Importance- Performance Analysis

EXTERNAL STAKEHOLDER ANALYSIS

The external customers perceive that the service level offered is higher than their desired service level. The Service Division is offering a high quality service. To enhance external customer satisfaction, improvement efforts must be targeted, in order of priority:

- 1- On-Time delivery (OTD) external is by far the most important attribute and the perceived performance is poor. Urgent action is needed.
- 2- Inspection report delivery time: There is big variation in this process, 40% of the points are outside specifications. Is the second parameter in which the efforts must be targeted to reduce variation.
- 3- Overdue invoices is ranked the parameter with better performance (desired or more than desired). Additionally it is the less important, it falls between excess and appropriate area.

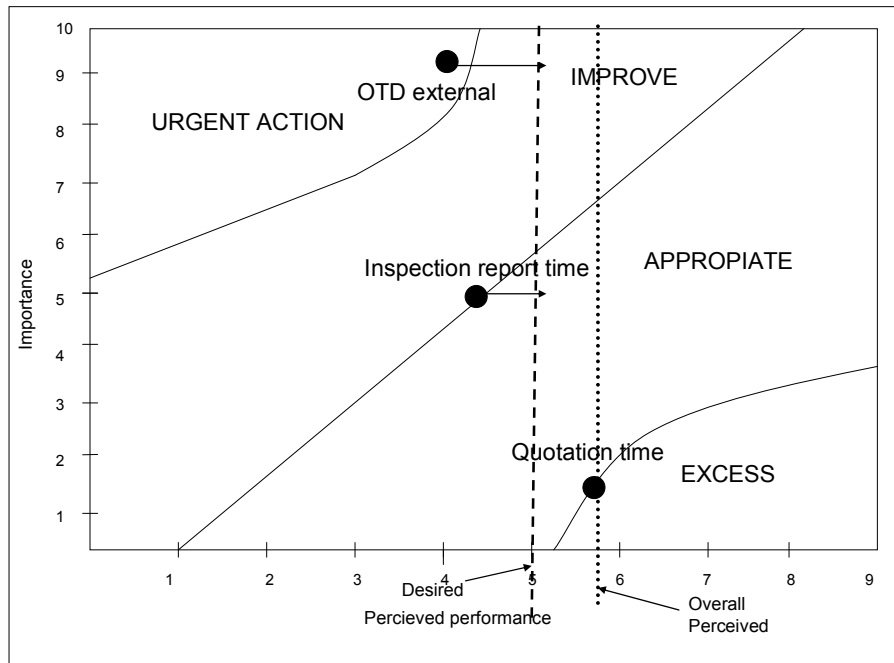


Figure 78- External customer Importance- Performance Analysis

Model credibility

Credibility is reflected in the willingness of persons to base the decisions on the information obtained from a model. It is one of the most important things. The model has proven to be credible. It is easy to understand for the managers. The main factors that enhance the credibility are:

- The managers understand the model and the assumptions
- The managers have been involved in the project
- The model has been validated and verified by Peter Cronemyr, with a large industrial experience, and good reputation in the firm.
- The management commitment in quality and customer communication issues

CONCLUSION

Understanding process variation and SPC monitoring are vital for a Six Sigma process management. SPC is a continuous health check of the process. The bar charts are a tool to represent the capability of the process in an easy way but they do not inform whether the process is having shifts in the behavior. The problem is that the specification limits for this capability are not made according to the customer needs. The main conclusion is that on time delivery external is the process in which continuous improvement efforts must be targeted. All the KPI's have been analyzed and the questions that the model must answer are summarized in the following tables:

Supplier on time delivery: Urgent action is needed. It is the most important and has a bad perceived performance. 40 percent of the deliveries are situated in the severe dissatisfaction area. Therefore is need to change the distribution centering i.e. the actual target value (on time) to 10 days before confirmed date. If the delivery is before the confirmed date, the associated warehouse cost and hidden credit paying before make the necessity to set LSL= -20 days. An SPC monitoring of the difference between confirmed and delivery date is recommended.

Invoices sent late: Improvement is needed. It is the second most important KPI and the easiest to improve. The invoice plan must be followed. Every deviation from the invoice plan is considered a bad performance. In this case is not needed SPC monitoring. The KPI is a good indicator.

Overdue invoices: It is the third in improvement priority and the less important KPI. The majority of the invoices are paid in a few days. They have a big repercussion in the KPI calculation but small in the real problem, the hidden credit. Therefore, we propose to count as overdue invoices the invoices paid more than 10 days late.

Quotation time: This attribute is ranked by the customers as the less important and with better performance. All of them are very positive with the performance. The majority of the points fall into the attractive area (less than 7 days late).

Inspection report: The customers think that this KPI is the second most important. The zone of tolerance is situated between 30 and 45 days. Inspection reports given in less than 30 days lead to customer satisfaction and in more than 45 days to customer dissatisfaction. Reports in less than 7 days are considered a bad performance because the customer feel that the quality of the report can not be good.

On time delivery external: It is by far the most important process. In maintenance work, the external stakeholders want the delivery as soon as possible. They prefer to receive the delivery before the confirmed date than on time. If the delivery is late they can run into a lot of problems.

-Section V-

Discussions and Conclusions

Today, firms compete with services rather than goods. Large service organizations are beginning to use Six Sigma as continuous improvement tool. An important part of the Six Sigma methodology is the calculation of number of defects in the process, i.e. points outside the specification limits. Unlike goods quality, which can be measured objectively by number of defects, in service goods the setting up of specification limits is a complicated issue because it is marked by the use and expectations among the different customers. As Six Sigma was originally created for manufacturing, this crucial fact is not contemplated in the Six-Sigma roadmap Define-Measure-Analyze-Improve-Control (DMAIC).

In this thesis we presented a model to solve this issue and set the specification limits according to the customer expectations in services organizations. A review of relevant literature has been used to develop a new integrated model with ideas from Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, the Trade-Off importance. A survey was carried out for 18 external and internal customers of the service division of Siemens Industrial Turbomachinery AB.

The output of the model is a graphic. The visual representation in the model of the Voice Of the Customer, the Voice Of the Data (VOD) and the Voice Of the Experience (VOE) creates value out of the data in one single graphic that cannot be attained through the use of either method alone. It makes this model a credible and very powerful tool not just to set the specification limits but also, to set strategic directions, for a comprehensive service quality measurement and to improve the target setting in the Six Sigma projects.

The line that separates black (defect) and white (non-defect) in service processes is diffuse because is market by the customers. This thesis is a contribution of a better understanding of what the customers think that is white, what the customers think that is black and which is the approximate line that separates black and white.

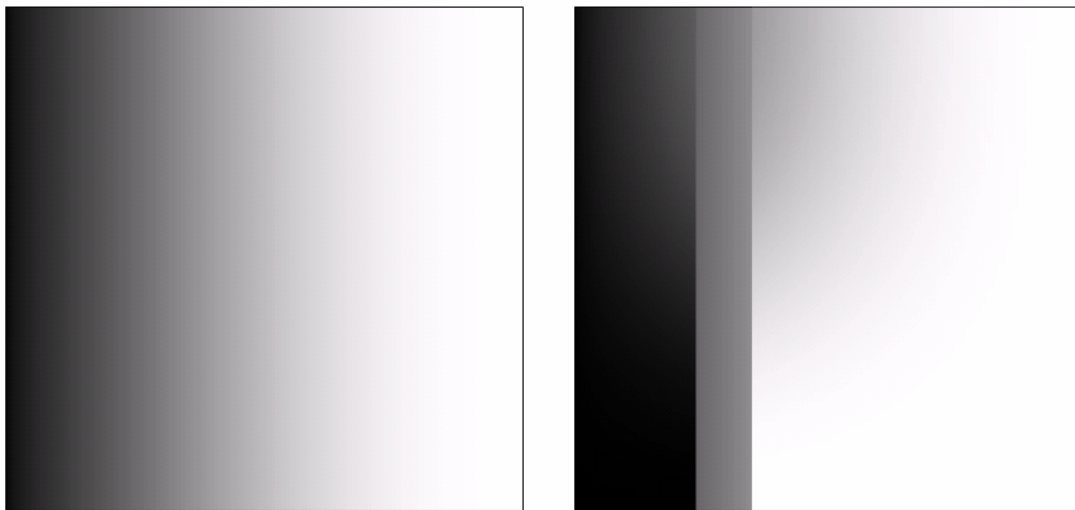


Figure 79

Practical implications

The following model (figure 81) analyzes the three dimensions used in this thesis. As a basis every organization uses the experience and Know-How. However this does not give any real competitive advantage. Other organizations besides this experience they monitor the historical

data to detect problems in the performance. The next step for the organizations is to listen to the customers, to link the experience with the historical data and with the customer expectations.

The Service Division, SIT AB, uses the experience, Know-How and the historical data in Six Sigma projects with very good results. It is currently between STAGE 1 and STAGE 2 of the proposed model (see figure 81).

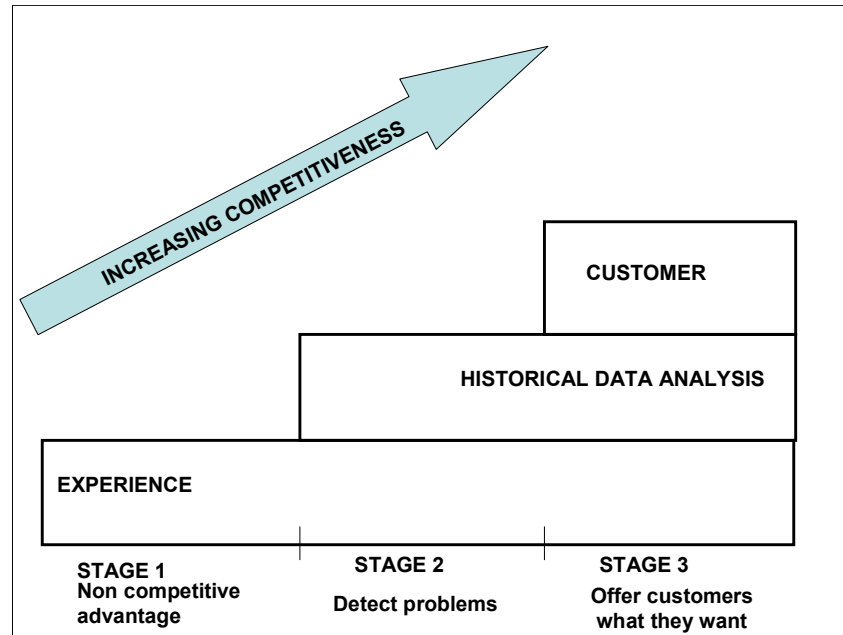


Figure 80- Proposed 3-Stage model for service excellence

But why do the organization hide the historical data in excel sheets with a lot of non relevant information. Why is only monitored the performance with a Key Performance Indicator? The historical data, well presented and interpreted can give extremely valuable information. The application of SPC would bring to detect problems in the process, STAGE 2.

In this thesis we have introduced a new way to communicate to customers. To know what they want, how they want it, what is really important for them and which are their perceptions about the service. The presented model links the three dimensions, experience, historical data and customer expectations.

The organization has the specialist to analyze the data, the proposed model, the historical data, 100 years of experience and Know-How and the most important, manager commitment. Why not use them? Why not go to STAGE 3? And offer to the customers what they really want.

Managerial implications

This study is of interest for Siemens Industrial Turbomachinery AB managers. It will close the control loop and will allow the change of the traditional bar charts for an SPC continuous health check. The real process sigma of the process can be calculated and the organization will use Six Sigma in its full potential.

The benefits in the SIT AB Service Division of the present study have a number of practical applications for service managers. It has proved to be a robust model to set the specification limits and proposes a new way to listen to the customers.

The study has the strength that analyzes the internal and external KPIs from a general and objective perspective. The relative importance together with the actual perceived performance and the Kano classification is very powerful to analyze the weakness, target setting, the improvement directions and prioritisation of Six Sigma projects. The complete analysis, presented in a systematic roadmap, allows a comprehensive service quality measurement. This model would work in its full potential in service companies with Six Sigma or SPC policies.

Limitations risks, disadvantages and avenues for further research

This research has three main limitations, first, this is the first attempt to create a model to transform customer expectations into specification limits, there are a few articles published about this issue. We used for the first time the trade-off importance model and the Kano line drawing with more than 2 points. The proposed model must be further validated in future research.

Second, the measurement of customer satisfaction was carried out using a single-item scale, and it was therefore not possible to estimate its reliability. We doubt of the robustness of SERVQUAL one-column format, further research is needed to extract the real customer satisfaction.

Third, this study is applied in a single service division, with a relatively small sample. Ideal research should be conducted using multiple industries in order to ensure that the model is generalizable.

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APPENDIXES

APPENDIX I- Roadmap to translate customer expectations into specification limits

Abstract: We present a two-stage methodology. The first stage is the questionnaire design and the second questionnaire analysis. These steps are intended as a baseline from which the users can develop modify and redefine their own unique methodology.

QUESTIONNAIRE ROADMAP

Step 1- Select attributes

If one attribute is under study, it is interesting to know whether is important comparing with other attributes. Select two more attributes for this analysis. When the analysis is done with two attributes, select one more.

When the number of attributes is greater than three (not recommended), instead of using the Trade off importance model, use the ranking model.

Step 2- Gather historical data

It is a very important step. Guarantee that the data is representative of the whole population. Plot the Histogram and the Box plot. Eliminate the out layers in the box-plot and note the values of the median, first quarter, third quarter maximum and minimum.

Step 3- Select important satisfaction-performance points

Having the histogram and box-plot information, wonder the satisfaction-performance points that you would like to ask. It is the most complicated part. Try to ask points that you do not have any idea of the answer. (Maximum 5, recommended 3) Do not ask questions that the answer would be obvious.

Step 4- Select scale for minimum service level

When asking for minimum acceptable service level, it is preferably good to have the same scale and units in all the attributes. In this way the customer is forced to think where to situate the minimum service levels, some times near zero and others near the maximum.

Step 5- Insert the values in the questionnaire

Insert the satisfaction points in the Kano questions, the scale for the minimum service level, and insert the box plot numbers that you have from step 3 into the trade-off importance model.

Step 6- Questionnaire verification

Guarantee that the questionnaire is short and takes less than 5 minutes. Select 2-4 persons with knowledge in the process to verify the questionnaire.

- Whether there are questions with an obvious answer, i.e. the majority of the customers will answer the same (VERY IMPORTANT)
- Whether you found difficulties to understand the instructions
- Other format questions that could be added/changed
- Whether the length is adequate
- Whether the values in the questions are realistic
- General suggestions for improvement

Step 7- Questionnaire hand in

If possible, hand in the questionnaire personally with a face to face interaction explaining the purpose of the study. Otherwise send it by email and ask the customers to return it by scanned email or fax. It is important to have minimum 80% return rate, the sample size must be minimum 10 customers.

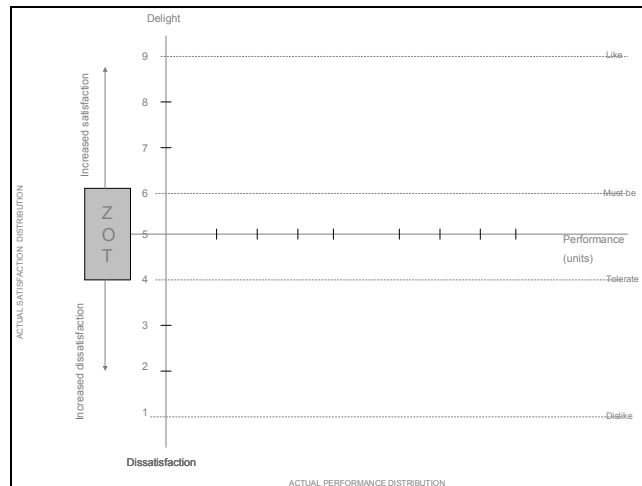
ANALYSIS ROADMAP

Step 1- Questionnaire analysis

Plot the histogram of the minimum service level, actual performance and trade off importance model. Plot every answer satisfaction line from the Kano questionnaire. Decide which line, or mixture of lines describes better the customer opinion. In case of different opinions try to stratify the data. If the sample is large do statistical test to find out whether there are significant differences between different customers.

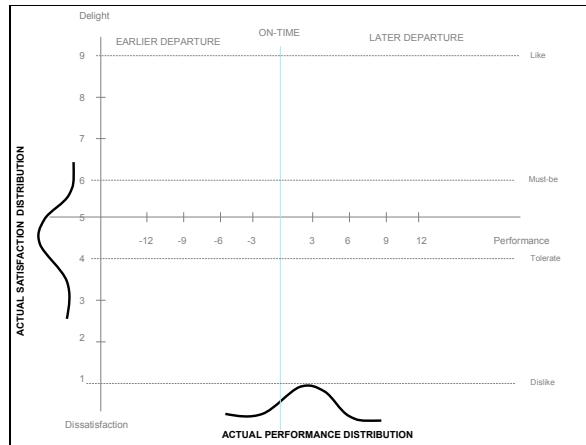
Step 2- Draw the model template

Draw the baseline for the model, it must look like this:



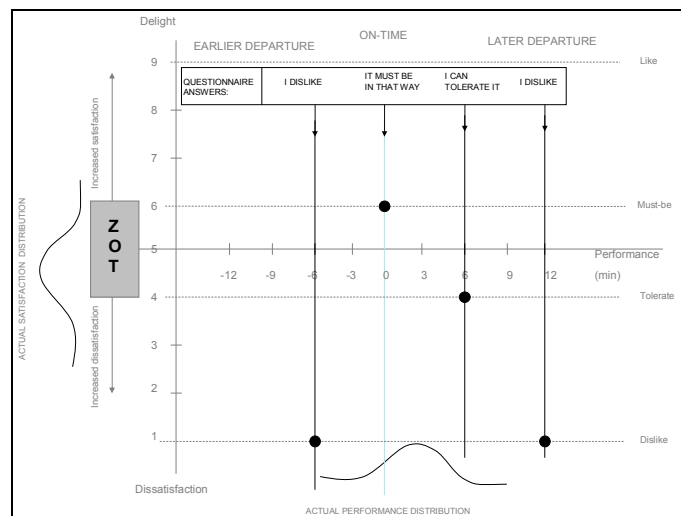
Step 3- Plot the actual performance and the units

Plot the performance units in the horizontal axis. Plot the Box Plot of the actual performance in the horizontal axis. Plot the perceived satisfaction performance in the vertical axis, if it is a big sample; more than 20 draw the box plot, for small sample, plot the histogram.



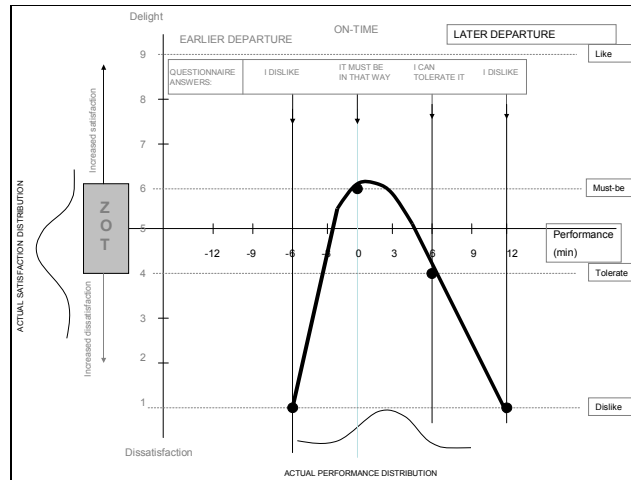
Step 3- Draw the satisfaction-performance points

With the decision from step 1. Draw the satisfaction performance points. Note that the minimum service level answered must be around the “I can tolerate it” line. Normally the customers tend to answer that they dislike it in the kano questions but they are more flexible in the minimum acceptable service level. It is very important to have it into account.



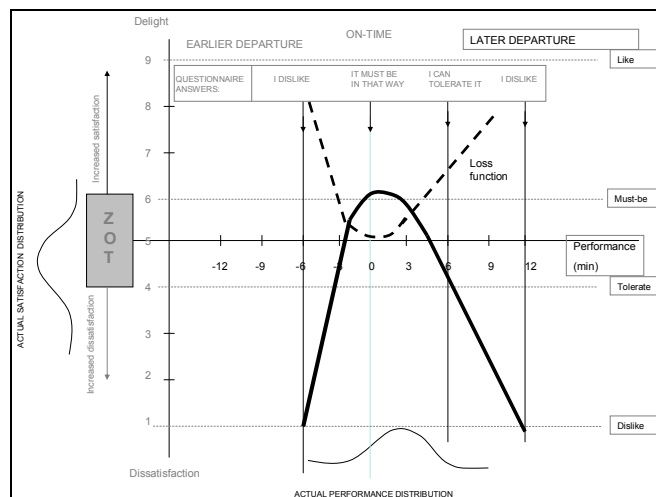
Step 4- Draw the satisfaction line

Link the dots. Sometimes is interesting to draw the lines according to Kano shapes. In this way the graphic can be separated in different stages. The attractive part, the indifferent part and the must-be part. It gives valuable information.



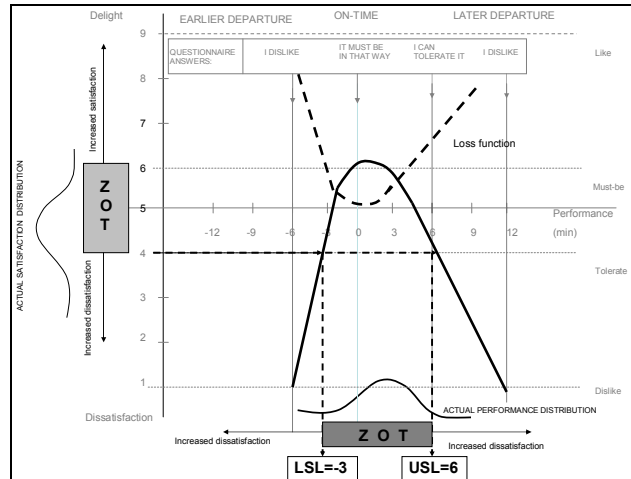
Step 4- Draw the loss function

According to Taguchi, (1987) the loss function establishes a financial measure of the user dissatisfaction with a product's performance as it deviates from a target value (the most desirable value of the parameter under consideration). A dissatisfied customer will change, it is a loss for the organization. It is very interesting to draw the loss function. The costs are always given more attention than abstract things such as customer satisfaction. Sometimes it is possible to quantify the slope of the loss function. For instance when speaking about overdue invoices, the hired credit can be quantified and the exact loss function can be draw. In other cases it is difficult to quantify, but inverting the satisfaction line we obtain a qualitative shape of the loss function.



Step 5- Set the specification limits!

The ZOT in the vertical axis mark the border between acceptable service and dissatisfying service. By translating this border to the horizontal axis (actual performance) the ZOT can be draw and we obtain the specification limits!



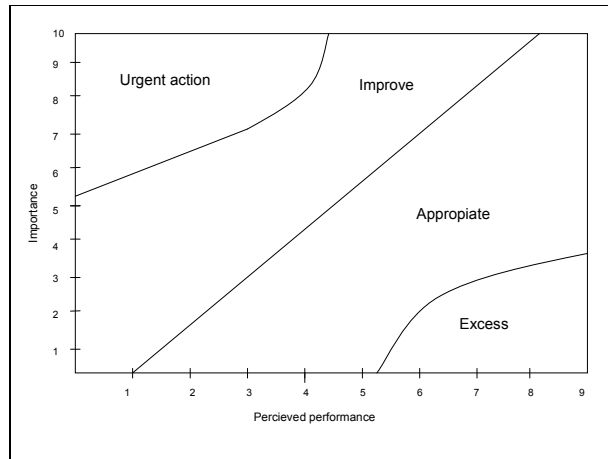
When the performance is lower than the ZOT in the satisfaction axis, it leads to dissatisfaction; therefore we can translate the ZOT to the performance axis and set the specification limits.

Step 6- Capability analysis

To perform the capability analysis we assume that the distribution is normal. In services, where the human is the main player it is difficult to have normal distributions with 95% confidence level. Therefore instead of doing the classical capability analysis, plot the histogram, set the specification limits and count the points outside the specification limits. Do a rate of % of conformance with specifications. Check whether the mean (in symmetric distributions) or median (in asymmetric distributions) is centered with the loss function. Quantify the loss of being outside the specifications and the savings of variation reduction.

Step 7- Set strategic directions!

Draw the scale from 1 to 9 in the horizontal axis and from 0 to 10 in the vertical axis. Get the information from the actual perceived performance and from the trade off importance analysis. Insert the values in IPA and the different attributes will be classified as:



- Urgent action
- Improve
- Appropriate
- Excess

APPENDIX II- Construction of the Importance Trade-Off Model

The basic idea of the new Importance Trade-Off model is that when explicit trade-offs between elements of the customer service mix are taken into account, different components of relatively importance emerge (Wetzels et al., 1995). The importance trade-off model is rather easy to answer and the output is the relatively importance of the attributes. It overcomes the “*everything is important*” problem because the customers are asked to select the best combination among a trade-off.

Example:
I think that the attribute 1 with the value X2 and the attribute 2 with the value Z2 would be the best combination.

Attribute 1	X1	X2	X3	X4	X5
Attribute 2	Z1	Z2	Z3	Z4	Z5

The new model: trade-off importance. It is rather easy to answer and has good results.

Points:	-2	-1	0	1	2
Attribute 1	X1	X2	X3	X4	X5
Attribute 2	Z1	Z2	Z3	Z4	Z5
Points:	2	1	0	-1	-2

Score of the different answers. In this case the customer prefers a better performance in attribute 1 (+1 point) and a worse performance in attribute 2 (-2 points)

Every variable gets 2 points if the customer strongly prefer a good performance in this attribute rather than in the other , 0 if the customer is indifferent between this two parameters performance, and -2 if the customer prefers a good performance in the other attribute. 1 and -1 are in between situations. The score obtained is $[-4n, 4n]$, for an easier interpretation it will be transformed into a 10 points scale $[0, 10]$

Variables:

q: Questionnaire number $q=1,2,\dots,n$
n: Total number of questionnaires
y: number of question $y=1,2,3$

Original points $[-4n, 4n]$

The addition of the points for all the questionnaires in each question

$$x_y = \sum_{q=1}^n x_{y,q} \quad \forall y = 1,2,3$$

Positive points $[0, 8n]$

The points obtained plus the maximum possible score. The maximum score is 2 points in all the questions that the variable x_y appears $(3-1)$ times per total number of questionnaires.

$$x_y' = x_y + 2 \cdot (3-1) \cdot n \quad \forall y = 1,2,3$$

10 points scale $[0, 10]$

Transformation to 10 points scale

$$x_y'' = \frac{10}{8 \cdot n} \cdot x_y' \quad \forall y = 1,2,3$$

APPENDIX III- External Customer Questionnaire

Dear Sir/Madam,

Our main focus in Siemens is You, the customer. In the Service Division we strive for a continuous improvement in all we do, we apply a strong six-sigma policy with the target of zero defects. We are interested in your impressions about the service that you receive. This feedback is very important when developing our customer-oriented service even further. We would be grateful if you would answer the following questionnaire.

If you require further assistance or advice in completing the questionnaire please do not hesitate to contact us.

Yours faithfully,



Ruben Gregorio
Siemens Service Division
ruben.gregorio.ext@siemens.com

DEFINITIONS:

SPARE PART QUOTATION delivery time: Time between your spare part quotation request until you receive the quotation.

INSPECTION REPORT delivery time: Is the time between the site job ends until Your company receives the inspection report.

DELIVERY BEFORE the confirmed date: The amount of days that you receive the spare part before your requested date.

DELIVERY AFTER the confirmed date: The amount of days that you receive the spare part after your requested date.

Days referred to working days.

Comments:

DIRECTIONS: Please, think how would you feel in the following situations and mark one option in each question. If you have any comment in the answer please write it in the intended space.

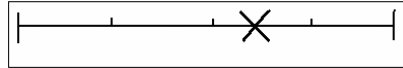
COMMENTS:

If the spare part DELIVERY IS 30 working days BEFORE the confirmed date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the spare part DELIVERY IS 10 working days BEFORE the confirmed date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the spare part DELIVERY IS ON-TIME, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the spare part DELIVERY IS 3 working days AFTER the confirmed date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the final INSPECTION REPORT is delivered in 2 months, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the final INSPECTION REPORT is delivered in 1 month, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the final INSPECTION REPORT is delivered in 1 week, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If you receive the SPARE PART QUOTATION in 20 working days, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If you receive the SPAREPART QUOTATION in 4 working days, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If you receive the SPAREPART QUOTATION in 10 working days, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	

MINIMUM ACCEPTABLE SERVICE LEVEL

DIRECTIONS: Please, mark in the continuous line your minimum service level, in which you would start to be dissatisfied.

Example:



I would **START TO BE DISSATISFIED** if the attribute is bigger than:

SPARE PART QUOTATION delivery time	WORKING DAYS	0	10	20	30
INSPECTION REPORT delivery time	MONTHS	0	1	2	3
Spare part DELIVERY BEFORE the confirmed date	WORKING DAYS EARLIER	0	10	20	30
Spare part DELIVERY AFTER the confirmed date	WORKING DAYS LATER	0	10	20	30

CURRENT SERVICE PERFORMANCE

DIRECTIONS: Based on your experiences with Siemens Service Division, think about the quality of service that we offer **compared with your desired service level** in the following attributes.

	Falls short of my desired service level Meets my desired service level Exceeds my desired service level								
INSPECTION REPORTING delivery time	1	2	3	4	5	6	7	8	9
DELIVERY ON-TIME	1	2	3	4	5	6	7	8	9
SPARE-PART QUOTATION delivery time	1	2	3	4	5	6	7	8	9
OVERALL PERCIEVED SERVICE PERFORMANCE	1	2	3	4	5	6	7	8	9

DIRECTIONS: If everything else would be the same mark the option that would fulfill better your desired service level.

Example:

I think that the attribute 1 with the value X2 and the attribute 2 with the value Z2 would be the best combination.

Attribute 1	X1	X2	X3	X4	X5
Attribute 2	Z1	Z2	Z3	Z4	Z5

If everything else would be the same WHICH WOULD YOU PREFER?					
INSPECTION REPORT delivery time	0,5	1	1,5	2	2,5
	☐	☐	☐	☐	☐
Spare part DELIVERY after the requested date	16	12	8	4	0
	☐	☐	☐	☐	☐

If everything else would be the same WHICH WOULD YOU PREFER?					
INSPECTION REPORT delivery time	0,5	1	1,5	2	2,5
	☐	☐	☐	☐	☐
SPARE-PART QUOTATION delivery time	22	17	12	7	4
	☐	☐	☐	☐	☐

If everything else would be the same WHICH WOULD YOU PREFER?					
Spare part DELIVERY after the requested date	16	12	8	4	0
	☐	☐	☐	☐	☐
SPARE-PART QUOTATION delivery time	4	7	12	17	22
	☐	☐	☐	☐	☐

If everything else would be the same **WHICH WOULD YOU PREFER? (mark one option)**

Spare part DELIVERY	☐ 2 days AFTER confirmed date ☐ 30 days BEFORE confirmed date
----------------------------	--

Thank you for your valuable contributions!

APPENDIX III- Internal Stakeholder Questionnaire

Dear,

In the Service Division we strive for a continuous improvement in all we do. In order to reach a best-in-class customer-oriented service we are performing a study for 'breaking the customer code'. By means of questionnaires and a conceptual model our target is to set the customers specification limits for the different attributes used in process control charts.

We are interested in your impressions, as an internal stakeholder, about our performance. This feedback is very important. We would be grateful if you would answer the following questionnaire.

If you require further assistance or advice in completing the questionnaire please do not hesitate to contact Ruben Gregorio or Peter Cronemyr.

Yours faithfully,

Ruben Gregorio
Siemens Service Division
ruben.gregorio.ext@siemens.com

DEFINITIONS:

Working Days customer OVERDUE INVOICE: Date we receive the invoice payment from customer– Date agreed payment

Working Days INVOICES SENT LATE: Date the invoice is sent to the customer - Date the invoice should have been sent to the customer

SUPPLIER DELIVERY AFTER requested date (working days): The amount of days that you receive the spare part after your requested date.

SUPPLIER DELIVERY BEFORE requested date (working days): The amount of days that you receive the spare part from the supplier before your requested date.

Internal Stakeholder comments:

DIRECTIONS: Please, think how would you feel in the following situations and mark one option in each question. If you have any comment in the answer please write it in the intended space.

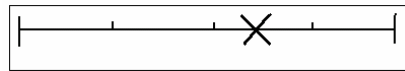
COMMENTS:

If the SUPPLIER DELIVERY IS 15 working days BEFORE the requested date for spare parts, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the SUPPLIER DELIVERY IS 5 working days BEFORE the requested date for spare parts, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the SUPPLIER DELIVERY IS ON-TIME for spare parts, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the SUPPLIER DELIVERY IS 5 working days AFTER the requested date for spare parts, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the customer pays the INVOICE 1 month BEFORE the payment date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the customer pays the INVOICE 5 working days AFTER the payment date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the customer pays the INVOICE 15 working days AFTER the payment date, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the INVOICE is SENT 1 month EARLY to the customer, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the INVOICE is SENT 5 working days LATE to the customer, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	
If the INVOICE is SENT 15 working days LATE to the customer, how would you feel?	☐ I like it ☐ It must be in that way ☐ I am neutral ☐ I can tolerate it ☐ I dislike it	

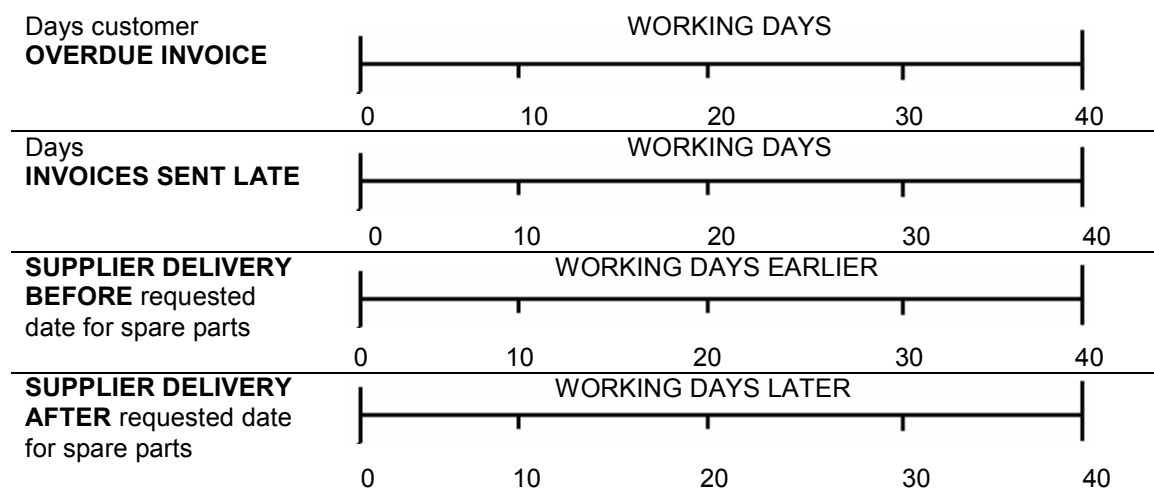
MINIMUM ACCEPTABLE SERVICE LEVEL

DIRECTIONS: Please, mark in the continuous line your minimum service level, in which you would start to be dissatisfied.

Example:

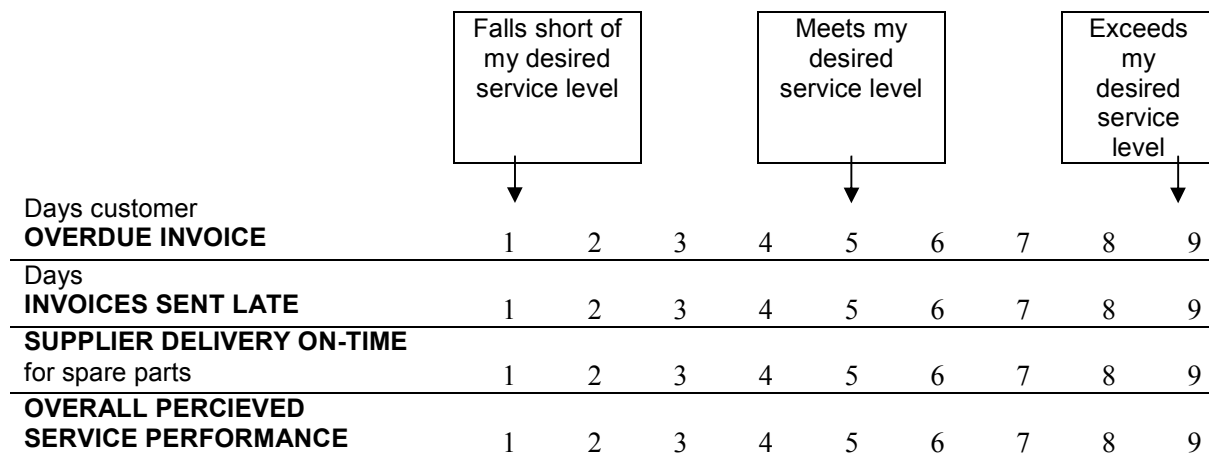


I would **START TO BE DISSATISFIED** if the attribute is bigger that:



CURRENT SERVICE PERFORMANCE

DIRECTIONS: Based on your experiences as an internal stakeholder, think about our current performance **compared with your desired performance level** in the following attributes.



DIRECTIONS: If everything else would be the same mark the option that you think would be better for the company.

Example:

I think that the attribute 1 with the value X2 and the attribute 2 with the value Z2 would be the best combination.

Attribute 1	X1	X2	X3	X4	X5
Attribute 2	Z1	Z2	Z3	Z4	Z5

If everything else would be the same **WHICH WOULD YOU PREFER?**

	AVERAGE WORKING DAYS				
Days customer OVERDUE INVOICE	0	10	20	30	40
	☐	☐	☐	☐	☐
Days INVOICES SENT LATE	40	30	20	10	0

If everything else would be the same **WHICH WOULD YOU PREFER?**

	AVERAGE WORKING DAYS				
Days customer OVERDUE INVOICE	0	10	20	30	40
	☐	☐	☐	☐	☐
SUPPLIER DELIVERY after requested date for spare parts	20	15	10	5	0

If everything else would be the same **WHICH WOULD YOU PREFER?**

	AVERAGE WORKING DAYS				
Days INVOICES SENT LATE	0	10	20	30	40
	☐	☐	☐	☐	☐
SUPPLIER DELIVERY AFTER requested date for spare parts	20	15	10	5	0

I WOULD PREFER... (mark one option)

SUPPLIER DELIVERY for spare parts received in...	☐ 3 days AFTER requested date ☐ 20 days BEFORE requested date
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**-PAPER A-
BREAKING THE CUSTOMER CODE- A MODEL TO TRANSLATE
CUSTOMER EXPECTATIONS INTO SPECIFICATION LIMITS**

Breaking the Customer Code

A Model to Translate Customer Expectations into Specification Limits

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Abstract

Purpose – The aim of this paper is to develop a model to help service organizations to set the specification limits according to the customer expectations.

Design/methodology/approach – A review of relevant literature is used to develop a new integrated model with ideas from the Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, “the Trade-Off Importance”. A survey was carried out for 18 external customers and internal stakeholders of the Service Division of Siemens Industrial Turbomachinery AB in Finspong, Sweden.

Findings – The model has demonstrated its robustness and credibility to set the specification limits. Additionally it is a very powerful tool to set the strategic directions and for service quality measurement.

Research limitations – First, articles published on this subject are few and there is no similar model in the literature to confirm or compare results. The proposed model must be further validated in future research. Second, this study is applied in a single service division, with a relatively small sample. Ideal research should be conducted using multiple industries in order to ensure that the model is generalizable.

Originality/value – As far as we know, this paper is the first attempt to create a roadmap to set the specification limits in services. Researchers should find the proposed model to fill the research gap. From a managerial standpoint, the practical benefits in Siemens Industrial Turbomachinery AB, suggest a new way of communicating to customers. The model will also improve the target setting in the Six Sigma projects.

Keywords Customer satisfaction, Service industries, Six Sigma, Specification limits, Kano model, SPC

Paper type Research paper

Introduction

During the last 20 years, there has been steady growth not only in the service sector but also in the service content of most products (Nilsson, 2002). Today some 70% of the GNP is derived from the service sector in the US and most European countries (Bergman and Klefsjö, 2003). Research scholars suggest that firms now compete with services rather than goods (Rust, 1998; Grönroos, 2000; Vargo and Lusch, 2004). Harris and Harrington, (2000) claim that the opportunity area for the twenty-first century is in the understanding and improvement of the service processes putting the customer in the centre of the issue. Phillips-Donaldson, (2005) in the article “*The Rock Stars of Quality*” states that the next breakthrough –and rock star (referring to the next guru in quality management)- is likely to come from the service sector.

The well-published financial benefits of Six Sigma in manufacturing are beginning to energize large scale application in services (Antony, 2006). Reported case studies of Six Sigma in services are scattered in a wide range of publications e.g. Cronemyr, (2007). Six Sigma is being used in banking,

healthcare, accounting and finance, public utilities, shipping and transportation, airline industry, education (Antony, 2006).

An important part of the Six Sigma methodology is the calculation of number of defects in the process, i.e. points outside the specification limits. However, unlike goods quality, which can be measured objectively by number of defects, in service processes the setting up of specification limits is a complicated issue because it is marked by the use and expectations among the different customers. As Six Sigma was originally created for manufacturing, this crucial fact is not contemplated in the Six-Sigma roadmap Define- Measure-Analyze-Improve-Control (DMAIC).

Walter A. Shewhart viewed quality from two related perspectives: the objective and subjective side of quality (Shewhart, 1931). The first perspective views quality as an objective reality independent of the existence of man. In contrast, the subjective side of quality considers what we think, feel and sense as result of the objective quality.

Despite differences in expression, the two aspects of subjectivity and objectivity have revolved around since the time of Aristotle, (350BC) (Kano et al., 1984), and some popular models are widely used both by academics and practitioners, to link these two sides e.g. the Kano model, Quality Function Deployment, Puga-Leal and Pereira, (2007) model, classification through direct questions, Importance Performance Analysis, Kansei engineering, conjoint experiments. However, none of these approaches serve to successfully transform the customer expectations into specification limits in services.

This paper aims resolve this issue developing a roadmap to systematically set the specification limits in services linking the subjective side of quality with the objective side. To do so, one integrated model is presented, combining ideas from the Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, the Trade-Off importance. The following section briefly reviews these five methods.

Kano model

Kano et al. (1984) developed a model to categorize the attributes of a product or service based on how well they are able to meet customer needs. The following are the popularly called Kano customer need categories.

- *Must-be requirements*: If these requirements are not fulfilled, the customer will be extremely dissatisfied. On the other hand, as the customer takes these requirements for granted, their fulfillment will not increase his satisfaction.
- *One-dimensional requirements*: With regard to these requirements, customer satisfaction is proportional to the level of fulfillment - the higher the level of fulfillment, the higher the customer's satisfaction and vice versa.
- *Attractive requirements*: Also called Whoh! or delighters, these requirements are the product criteria which have the greatest influence on how satisfied a customer will be with a given product. Attractive requirements are neither explicitly expressed nor expected by the customer. Fulfilling these requirements leads to more than proportional satisfaction. If they are not met, however, there is no feeling of dissatisfaction.

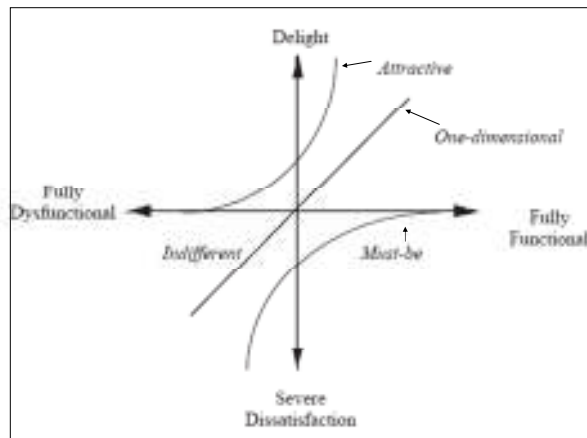


Figure 1.
Kano model of customer satisfaction.
Source: Pouliot, (1993)

SERVQUAL

In 1985, Parasuraman et al. developed the SERVQUAL instrument (refined in 1988, 1991 and again in 1994). The instrument consists of two sets of 22 statements: the first set aims to determine a customer's expectations of a service firm; while the second set seeks to ascertain the customer's perceptions of the firm's performance. The results of the survey are then used to identify positive and negative gaps in the firm's performance on five service quality dimensions. (Robison, 1999) According to Robison, 1999, there seems little doubt that in the past decade SERVQUAL has proven to be the most popular instrument for measuring service quality. SERVQUAL 3-column format is capable of specifically indicating the position of the zone of tolerance.

Berry and Parasuraman, (1991) defined the zone of tolerance as the range of service performance that a customer considers satisfactory. A performance below the tolerance zone will engender customer frustration and decrease customer loyalty. A performance level above the tolerance zone will pleasantly surprise customers and strengthen their loyalty. Several authors (e.g. Johnston, 1995; Cronin, 2003) consider that levels of service performance within the zone of tolerance are not perceived as different by customers.

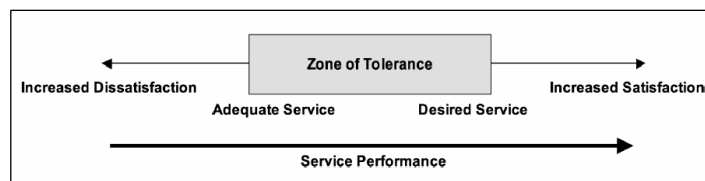


Figure 2. Variations within the zot are not perceived by the customers

Taguchi loss function

Taguchi changed the traditional view, that as long as a parameter lies within the specification limits, the financial loss is zero and as soon as a parameter has exceeded one of the tolerance limits, the financial loss is large. For Taguchi, every deviation from the target value means a loss which grows as the deviation increases (Bergman and Klefsjö, 2003). This view puts the customer at the centre of the issue (Lofthouse, 1999).

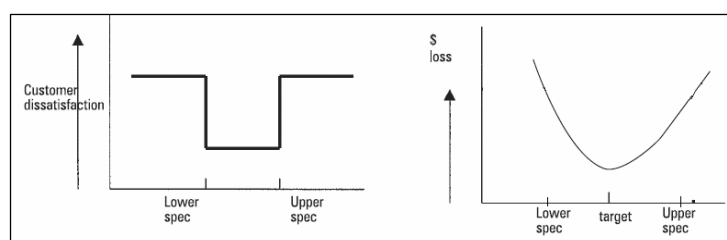


Figure 3. a)traditional view b) Taguchi loss function

For further details see Taguchi, (1987) or Phadke, (1989), for a short general overview with down-to-earth language see Lofthouse, (1999).

The Importance Performance Analysis (IPA)

The Importance Performance Analysis (IPA), introduced originally by Martilla and James (1977), and modified by Slack (1994), allows a company to identify which attributes of its products or services should be improved to become more competitive in the market. Typically, data coming from customer satisfaction surveys are used to build a matrix, where the importance is shown by the y-axis and the performance of the attribute by the x-axis. Although the IPA model of quality attributes is a simple structure, it can provide much useful information about a company's quality performance (Tontini and Silveria, 2007).

The Trade-Off Importance model

The customer tends to consider everything important; we call it the “everything is important” problem. We developed a new approach for relative importance measurement, the Importance Trade-Off analysis. The basic idea of the model is that when explicit trade-offs between elements of the customer service mix are taken into account, different components of relative importance emerge (Wetzels et al., 1995).

Three pairwise comparisons (the trade-off questions) of two attributes give the relative importance of three attributes.

The answers are analyzed and translated into one importance scale from 1 to 10 points.

If everything else would be the same WHICH WOULD YOU PREFER?						
INSPECTION REPORT delivery time	0,5	1	1,5	2	2,5	
	☐	☐	☐	☐	☐	
Spare part DELIVERY after the confirmed date	16	12	8	4	0	
			DAYS LATE			

Figure 4. The new model: trade-off importance. One out of three trade-off questions

Model construction

Witell and Löfgren (2007) made a literature review of 29 research articles; they found that the Kano model is often modified or used in combination with other methods. In the literature there is an agreement about the limitations of using the available methods alone and the need of an integrated approach (e.g. Tan and Pawitra, 2001; Puga-Leal and Pereira, 2007; Yang, 2003).

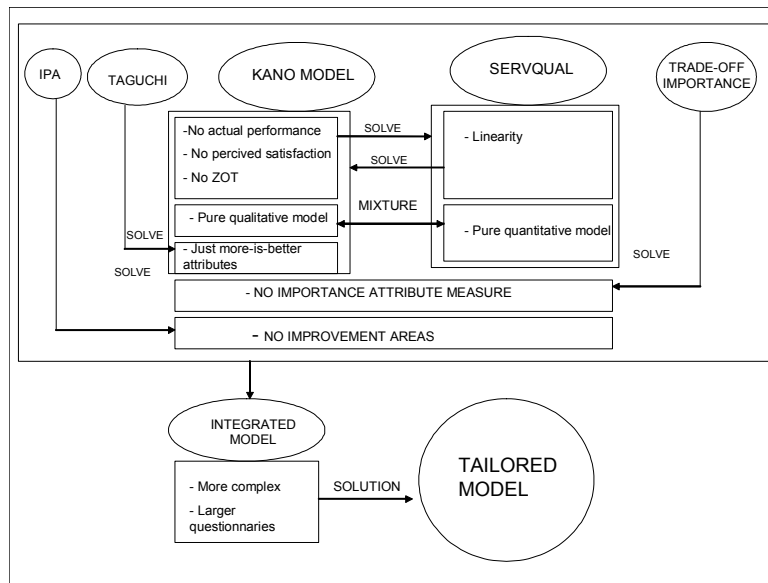


Figure 5. Problem analysis of the different models

Kano model modification and integration in SERVQUAL

The Kano model is a purely qualitative model, it does not inform about the actual situation in the curve, for example, one attribute is classified as “must be” but the model does not give any information whether the current performance is in the severe dissatisfaction area or in the neutrality area.

To solve this problem it is interesting to introduce the zone of tolerance concept into the Kano model. In the special issue in fall 1993 of the *Center for Quality Management Journal*, Pouliot presents the following theoretical issue. Pouliot, (1993) derive the lines of the Kano evaluation table. He proposes to plot the axes of the Kano Diagram and label vertical levels of the graph with the wordings of the answers to questions on a Kano questionnaire. The “Must be” level is only a little above neutral because Must-be is only a weak statement of satisfaction, it is more a statement of lack of dissatisfaction, though certainly more positive than neutral. Symmetrically, “can live with” is not a strong statement of dissatisfaction, but its grudging acceptance is more negative than neutral. For every classification he proposes three different lines; Three for attractive, three for must be and three for indifferent.

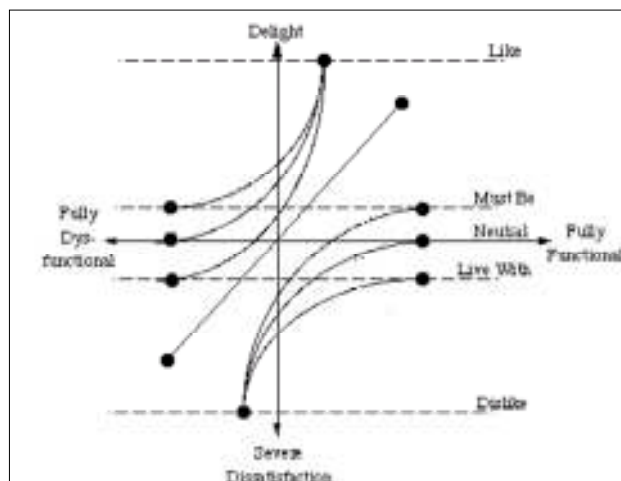


Figure 6. Proposed lines, observe that there is not only one line for every classification. Source: (Pouliot, 1993)

Integrating SERVQUAL into the Kano model, in the vertical axis, the area between “It must be like that” and “I can tolerate it” is the satisfactory service level where we can introduce the subjective zone of tolerance.

In the horizontal axis, we introduced numbers, actual performance in days, months... Every process has a variation, therefore is interesting to plot the box plot of the actual performance in days, months... in the objective axis.

The satisfaction-performance lines allow to translate the subjective zone of tolerance to the objective zone of tolerance. It allows to know the percentage of the points of the service offered that fall into the satisfaction, dissatisfaction or delight area.

Despite SERVQUAL's wide use by academics and practitioners in various industries and in different countries, a number of studies have questioned its conceptual and operational bases, (e.g. Morrison, 2004, Lewis and Mitchell, 1990, Smith, 1995).

According to Tan and Pawitra (2001), three main areas for further improving SERVQUAL can be identified. First, SERVQUAL assumes that the relationship between customer satisfaction and service attribute is linear i.e. all the attributes are one-dimensional. This is not in line with the Kano ideas. In addition, SERVQUAL is recognized as a continuous improvement tool. There is however, no element for innovation. Third, SERVQUAL provides important information on the gaps between predicted service and perceived service but it is not able to address how the gaps can be closed.

Kano model can help address the innovation issue against SERVQUAL. Because attractive attributes are a source of customer delight, this is one area where efforts for improvement should be targeted (Tan and Pawitra, 2001). Introducing Kano model into SERVQUAL can counter the linearity problem.

Integrating and modifying SERVQUAL and Kano model, some problems have been addressed. However, there still are some more:

Kano model just considers more-is-better attribute: Taguchi, (1987) considered four categories of quality characteristics: higher-the-better (e.g. computer's performance), lower-the-better (e.g. waiting time in a queue), nominal-is-best (e.g. time schedules) and asymmetric.

The Kano model can be used just with more-is-better attributes. We developed a systematic approach to draw the four categories satisfaction-performance curves without the use of the Kano classification table.

The relative importance of the attributes is not analyzed: In the literature there is an agreement about the necessity of analyzing the relative importance of the attributes (e.g. Deming, 1986; Walker and Baker, 2000). When visiting your doctor, getting the proper diagnosis and treatment seems more essential than having a good selection of magazines available in the waiting room, though both may be necessary for a favorable experience (Walker and Baker, 2000). Customers may consider some features of a service as more necessary or essential to their experience than others. Kano model and SERVQUAL do not analyze the relative importance of the attributes. By integrating the new Trade-Off Importance model the information about the relative importance is obtained.

No improvement directions: Kano model and SERVQUAL do not have any strategic direction approach for guiding after the results. The Importance Performance Analysis, with information from the trade off importance model and

SERVQUAL together with the Kano classification helps to guide to the improvement directions.

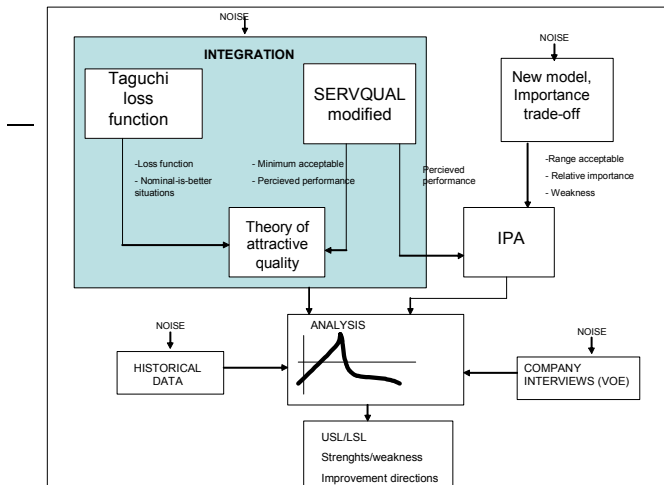


Figure 7.
Proposed model

Application in the Service Division, Siemens Industrial Turbomachinery AB (SIT)

Cronemyr, (2007) developed a model for process management that is being used in SIT AB. According to this approach the first step is mapping processes, second run Six Sigma projects and third go for the process control. Phase 1 and 2 are running successfully, and Phase 3 is not used in the right way. Analysis and follow-up of Key Performance Indicators (KPIs) are performed with bar charts with monthly average values. The decisions are made according to the difference of this value and one target without taking into account the process variation. The process control charts were developed in a previous project.

The setting up of the specification limits based on the real customer needs will allow the company to use a SPC control loop in the “Six Sigma way”.

Questionnaire design

Integrated approaches are normally time-consuming to answer and analyze, see for example, Yang, (2003); Tan and Pawitra, (2001). The most important constraint was that the questionnaire must take maximum 5 minutes to answer. It has three parts:

- i- *Kano modified* questions was for obtaining the satisfaction-performance lines, i.e. to link the subjective quality with the objective quality.
- ii- *SERVQUAL modified*; the purpose was to measure internal and external customers’ perceived performance and to measure their minimum service level.
- iii- *Trade-Off Importance model* was designed to extract the customer relative importance of the different attributes.

Sample and data collection

We selected 9 internal stakeholders, the process owners of the different Key Performance Indicators (KPIs) and 9 external customers represented by people from finance and engineering at different companies and countries.

It is very important to have a high return rate. For example, (Yang, 2003), made a survey with an integrated approach, 1400 persons were mailed randomly, resulting in 150 valid questionnaires. In this situation the analysis of

the questionnaires is useless because it does not represent the general opinion. Maybe, only the customers that are very satisfied or dissatisfied have answered.

Analysis

The model was applied for the six main KPIs in the service division; we will illustrate the analysis with an example (because of company confidentiality the real data have been somewhat manipulated). Inspection report delivery time is the time between the site job ends until the customer receives the inspection report.

The vertical axis represents the subjective side of quality, the customer perceptions of this attribute. The zone of tolerance is drawn between the “must be” and “I can tolerate it” line, in this zone the customers will not feel the variations. In the satisfaction area, the expectations are met, performance higher than the satisfaction area will lead to customer delight and lower to the ZOT will lead to dissatisfaction.

The horizontal axis represents the objective side of quality, the attribute actual performance and its current in a box-plot gathered from historical data. The satisfaction-performance lines represent the customer satisfaction in function of the inspection report delivery time (in days). With the satisfaction-performance lines we can translate the subjective zone of tolerance to the objective ZOT.

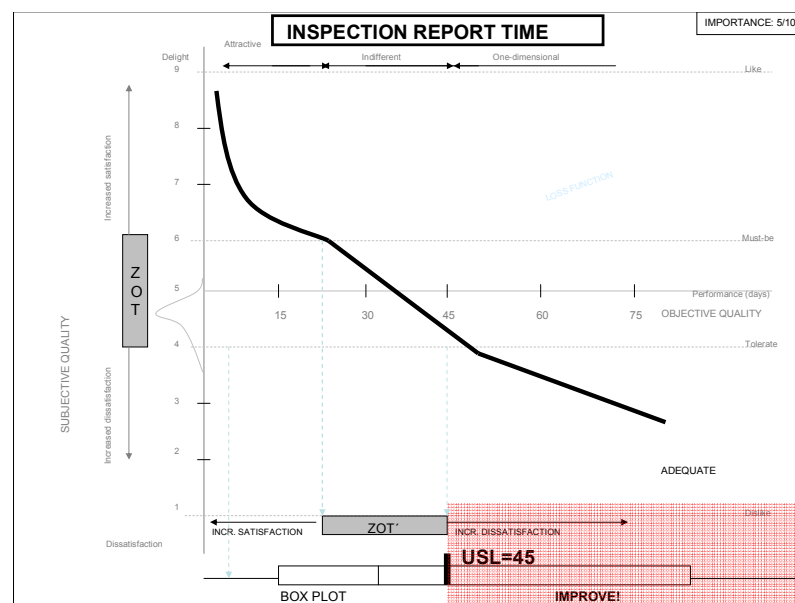


Figure 8.
Final graphic

In the graphic above there are three different stages:

Satisfaction area: Inspection reports between 20 and 45 days are in the indifferent area, the expectations are met the variations within this zone would have marginal effect in the customers' perceptions of the service.

Delight area: Inspections in less than 20 days is a delighter. This differentiates from the competitors.

Dissatisfaction area: Inspections in more than 45 days lead to external customer dissatisfaction; it is a bad performance in the process.

According to Bergman and Klefsjö, (2003), the quality of a product or service is its ability to satisfy, or preferably exceed, the needs and expectations of the

customers. As long as the satisfaction-performance line is within the satisfaction and delight area, the organization is offering a high quality service. With more than 45 days of inspection report delivery time the customers start to be dissatisfied, The specification limit will be marked in 45 days.

Capability analysis and target value

With the specification limits set by the customers, the real number of defects in the process can be calculated. To perform the capability analysis we assume that the distribution is normal. In services, where the human is the main player it is difficult to have normal distributions with 95% confidence level, it is needed to transform the data. Instead, we propose to calculate the percentage of conformance with specifications. There are tables to transform the yield into a sigma value.

Defining the quality loss as the customer dissatisfaction, by inverting the satisfaction-performance lines, the associated qualitative loss function can be drawn in the histogram. The loss function is very useful to understand that it is not just important to meet the specification limits. It is also important to center the distribution in the right area to maximize the customer satisfaction and minimize the associated cost.

This way of thinking was first introduced by Genichi Taguchi in the 1950s and early 1960s. Taguchi methods are claimed to have provided as much as 80 per cent of Japanese quality gains (Lofthouse, 1999).

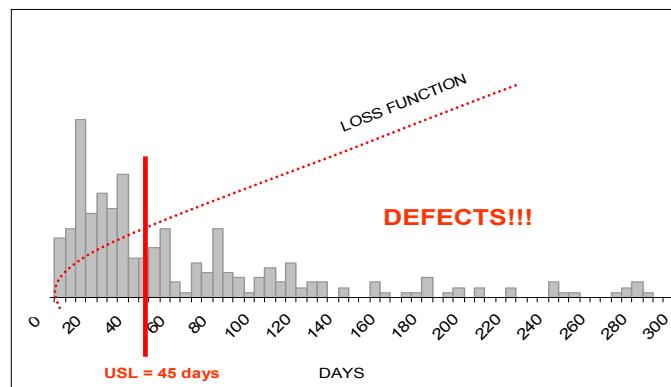


Figure 9.
Capability analysis

Improvement directions

The Importance Performance Analysis is a very simple, visual and useful tool. The vertical axis represents the attribute importance obtained from the “trade off importance model” and the horizontal axis the attribute perceived performance from SERVQUAL.

Inspection report perceived performance does not reach the desired service level. However the customers think that it is not crucial (importance 5/10).

To enhance customer satisfaction, improvement efforts must be targeted in the attribute A. Improving attribute C will have a marginal effect in the customer service perception.

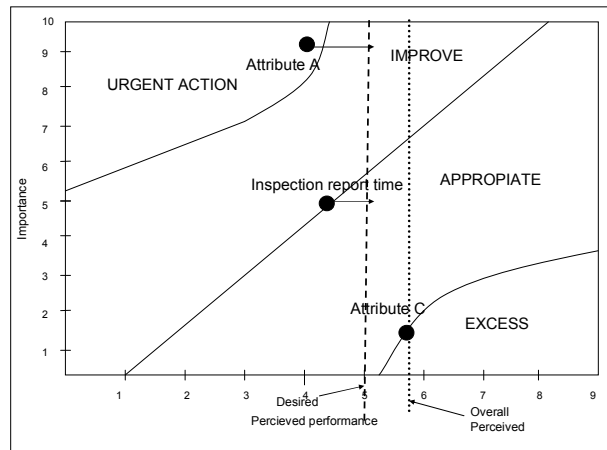


Figure 10.
IPA analysis

Practical implications

As a basis every service organization uses the experience and Know-How for service excellence. However this does not give any real competitive advantage. Other organizations besides this experience they monitor the historical data to detect problems in the processes. The next step for the organizations is to listen to the customers, to link the experience with the historical data and with the customer expectations.

The Service Division, SIT AB, uses the experience, Know-How and the historical data in Six Sigma projects with very good results. It is currently between STAGE 1 and STAGE 2 of the proposed model (see figure x).

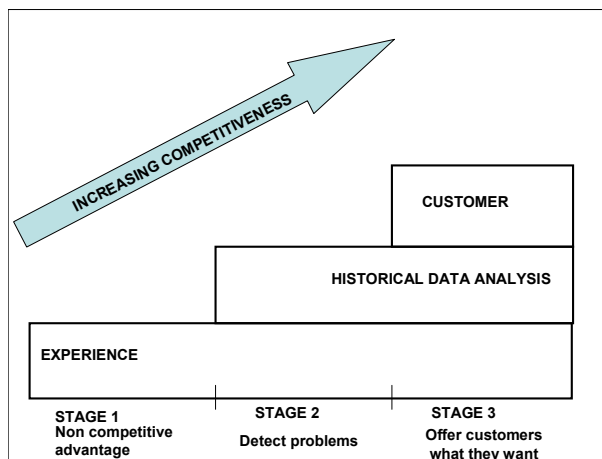


Figure 811. Proposed 3-Stage model for service excellence

But why does the organization hide the historical data in excel sheets with a lot of non relevant information. Why is only KPIs monitored? The historical data, well presented and interpreted can give extremely valuable information. The application of SPC would bring the company to STAGE 2, i.e. to detect problems in the process.

In this paper we have introduced a new way to communicate to customers. To know what they want, how they want it, what is really important for them and which are their perceptions about the service. The presented model links the three dimensions, experience, historical data and customer expectations and will allow the organization to go to STAGE 3 and offer the customers what they want.

Conclusions and recommendations

Today, firms compete with services rather than goods. Large service organizations are beginning to use Six Sigma as continuous improvement tool. An important part of the Six Sigma methodology is the calculation of number of defects in the process, i.e. points outside the specification limits. Unlike goods quality, which can be measured objectively by number of defects, in service goods the setting up of specification limits is a complicated issue because it is marked by the use and expectations among the different customers. As Six Sigma was originally created for manufacturing, this crucial fact is not contemplated in the Six-Sigma roadmap Define- Measure-Analyze-Improve-Control (DMAIC).

In this paper we presented a model to solve this issue and set the specification limits according to the customer expectations in services organizations. A review of relevant literature has been used to develop a new integrated model with ideas from Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, the Trade-Off importance. A survey was carried out for 18 external and internal customers of the service division of Siemens Industrial Turbomachinery AB.

The output of the model is a chart that analyzes the most important KPIs in the Service Division from a general and objective perspective. The visual representation in the model of the Voice Of the Customer, the Voice Of the Data (VOD) and the Voice Of the Experience (VOE) creates value out of the data in one single graphic that cannot be attained through the use of either method alone. It makes this model a credible, robust and very powerful tool not just to set the specification limits but also, to set strategic directions, for a comprehensive service quality measurement and to improve the target setting in the Six Sigma projects.

The line that separates black (defect) and white (non-defect) in service processes is diffuse because is market by the customers. This paper is a contribution of a better understanding of what the customers think that is white, what the customers think that is black and which is the approximate line that separates black and white.

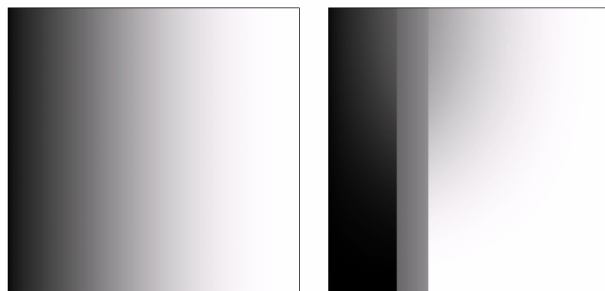


Figure 182

Managerial implications

This study is of interest for Siemens Industrial Turbomachinery AB managers. It will close the control loop and will allow the change of the traditional KPI bar charts for an SPC continuous health check. The real process sigma of the process can be calculated and the organization will use Six Sigma in its full potential.

The benefits in the SIT AB Service Division of the present study have a number of practical applications for service managers, mainly in organizations using Six Sigma or SPC policies.

Limitations and avenues for further research

This research has two main limitations, first, this is the first attempt to create a model to transform customer expectations into specification limits, there are a few articles published about this issue. We used for the first time the trade-off importance model and the Kano line drawing with more than 2 points. The proposed model must be further validated in future research.

Second, this study is applied in a single service division, with a relatively small sample. Ideal research should be conducted using multiple industries in order to ensure that the model is generalizable.

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