Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 4160 - 4175, 2005

USING QUALITY FUNCTION DEPLOYMENT TO EVALUATE GOVERNMENT SERVICES FROM THE CUSTOMER'S PERSPECTIVE

Chigako YAMAMOTO
Graduate School of Engineering
Hokkaido University
North 13 West 8, Kita-ku, Sapporo
060-8628 Japan
Fax: +81-11-706-6864
E-mail: chigako@gradus.net

Kunihiro KISHI
Research Associate
Graduate School of Engineering
Hokkaido University
North 13 West 8, Kita-ku, Sapporo
060-8628 Japan
Fax: +81-11-706-6864
E-mail: kishi@eng.hokudai.ac.jp

Fumihiro HARA
Director
Hokkaido Development Engineering Center
South 1 East 2, Chuo-ku, Sapporo
060-0807 Japan
Fax: +81-11-271-3028
E-mail: hara@decnet.or.jp

Keiichi SATOH
Professor
Graduate School of Engineering
Hokkaido University
North 13 West 8, Kita-ku, Sapporo
060-8628 Japan
Fax: +81-11-706-6864
E-mail: kkaku@eng.hokudai.ac.jp

Abstract: In this study, we examined the application of Quality Function Deployment (QFD) to the evaluation of government services in view of the customers' perspective. We studied winter road maintenance services of the City of Sapporo as an example of QFD application to road maintenance, a public service. Using a descriptive questionnaire, we identified the items of dissatisfaction among road users and quantified their importance. We show QFD, which is based on the philosophy of designing a product by converting market needs into the technical aspects required for the product to meet those needs, to be highly useful for such evaluation.

Keywords: customer evaluation, public service, winter road maintenance, quality function deployment (QFD), descriptive questionnaire, keyword analysis.

1. INTRODUCTION

This study uses Quality Function Deployment (QFD) to evaluate the government service of road maintenance from the perspective of the customers. It shows that QFD is highly useful for such evaluation. QFD is based on the philosophy of designing a final product by converting customer needs into the technical aspects required for the product to meet true customer needs. The theoretical framework of QFD was developed by Mizuno, S. and Akao, Y. (Mizuno, et al., 1978)[6]. QFD is a quality control (QC) method extensively used not only in manufacturing but also in services and other industries. Special methods of applying QRD to

services have also been developed (Ofuji, et al., 1990)[8].

Because road maintenance is a service, albeit a public sector one, QFD has the potential for application in a manner similar to that for private sector services. It can be applied to evaluate government services from the customer's perspective, in addition to being a tool for design and QC. In this study, we attempted to apply QFD to winter road maintenance, which is indispensable for road users in cold, snowy regions. We report our use of QFD and its usefulness in evaluating road maintenance from the customers' perspective.

2. CONVENTIONAL SURVEYS ON CUSTOMER SATISFCATION WITH GOVERNMENT SERVICES

Customer Satisfaction (CS) Portfolio Analysis (Tokyo Data Bank, 2004)[15] and Analytic Hierarchy Process (AHP) (Saaty, et al., 1985)[13] are among methods generally used to survey residents' satisfaction with government services and/or their needs regarding such services.

CS Portfolio Analysis determines whether evaluation items should be "greatly improved," "improved," "left largely unchanged" or "left unchanged." Based on user ratings, the items are divided into 5, 7 or 9 levels of importance, and 5, 7 or 9 levels of satisfaction. These two ratings for each item are used to determine the degree of improvement necessary for that item. Such analysis has been conducted in Japan by Miyagi Prefecture (Miyagi Prefecture, 2004)[5].

AHP is a decision-making method developed by Prof. Saaty, T. L. It provides a means of making decisions or choices among alternatives, particularly where multiple objectives must be satisfied. AHP provides a structured framework that allows for the comparison of both qualitative and quantitative criteria to derive weights and establish priorities of alternatives used within the decision-making process. AHP allows decision makers to model a complex problem in a hierarchical structure showing relationships between the goal, objectives (criteria), sub-objectives, and alternatives. Joetsu City is one place that has done such a survey (Joetsu City, 2002)[3].

CS Portfolio Analysis and AHP have the following shortcomings in terms of residents' evaluation of government services: 1) because a selective questionnaire of items specified by the government is used, the survey cannot address issues that have not been recognized by the government; and 2) it is doubtful that a government could directly translate the survey results into the design of services; the results may need to be interpreted by professional engineers into measures that address the "true" needs of residents.

3. QUALITY FUNCTION DEPLOYMENT

3.1 History and Outline

Ofuji et., al. (1990)[8] reports as follow: after the Second World War, statistical quality control (SQC) was used extensively in the chemical industry in Japan. In that case, QC focused on production, because once a plant is established, the quality of its products is secured by SQC of production. From the 1960s onward, manufacturing industries, particularly those of the automotive sector, grew rapidly. New models were introduced in rapid succession, and QC shifted from SQC to total quality control (TQC).

These were the formative years of quality deployment (QD) in product development. Bridgestone Tire was one of first companies to use QD for this purpose. When Mizuno, S. and Akao, Y. published *Quality Function Deployment* (1978)[1], it provided a groundbreaking theoretical framework. They advocated using QFD to secure product quality at every phase of production, from the earliest stages of design through the final phases of development. Since then, many companies have been using QFD, including Mitsubishi Heavy Industries, Komatsu and Panasonic. Since 2003, QFD has been included in *Japan Industrial Standards* (JIS Q-9025: Improving Performance of Management Systems - Guideline for QFD) as a recommended QC tool (Japanese Standard Association, 2003)[7].

In the U.S., QFD gained widespread attention when presented in *The Journal of Quality Control* in 1983. QFD has been widely used by U.S. businesses, such as 3M, Boeing, Hewlett Packard and IBM. Even the Big Three automakers selected QFD as a standard QC tool (QFD Institute, 2004)[9]. In QS 9000, which was developed as a standard for U.S. automakers, use of QFD is compulsory for automotive parts suppliers (Iyobe, 2000)[2]. In the U.K., the University of Sheffield has been studying QFD. Businesses that have introduced QFD include Rover (Lowe, A. J., 2000)[4]. These examples show how widespread QFD has become.

3.2 Definitions

QFD is defined as the conversion of customer needs into the technical features of a product such that the product realizes customer requirements, and the systematic deployment of relationships between qualities of various parts/phases. Unlike SQC, data used in QFD are described as “language.” “Deployment” is a term that in QFD can mean either a breakdown of abstract demands of customers or technology, or use of a matrix that converts quality requirement weights to quality element weights.

In Figure 1, the left triangle indicates the customer. It is a “Deployment Diagram of Quality Requirements” that clarifies the Quality Requirements of customers based on the voices of Customers (VOC). The triangle at the top indicates technology. It is a “Deployment Diagram

of Quality Elements." The Quality Table converts Quality Requirements to Technical Elements and is often called a House of Quality (HOQ), from its shape.

One of the benefits of using QFD is that it provides a quality assurance system that includes the development phase of a new product, thereby reducing the development lead-time of a new product by designing it such that the quality addresses the VOC. This allows QFD users to take adequate product liability measures and to meet requirements of the ISO 9000 series and ISO 14000.

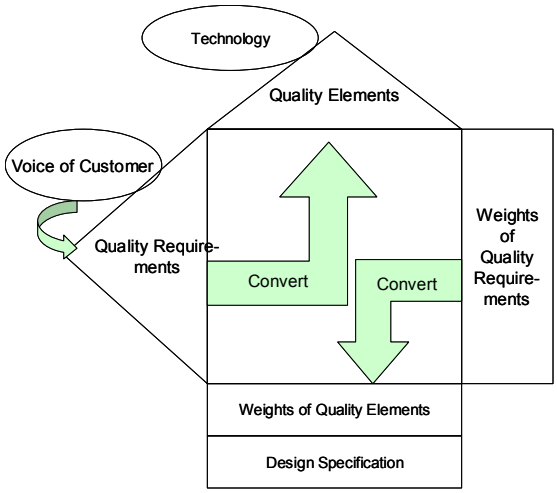

Figure 1. QFD Procedures

3.3 "Taken-for-Granted" Quality

Quality items called "Taken for Granted" are so fundamental that conventional products/services achieve them as a matter of course. Consequently, they are not specified by VOC in questionnaires although they are indispensable to secure the quality of the product. For example, it is assumed that the foundation of a prefab house must be solid. All customers expect this, even though they might not explicitly specify it. If Taken-for-Granted Quality is not satisfied, dissatisfaction can be great.

4. CASE STUDY OF QFD APPLICATION

4.1 QFD Procedure for Government Services

Because QFD considers "Taken-for-Granted" Quality, it gives different results from CS Portfolio Analysis or AHP. In addition, QFD converts VOC to technical elements called "Quality Elements." QFD has the advantage of designing "what should be done" to meet the "true" needs of customers.

4.2 Case Study: Winter Road Maintenance in Sapporo

In applying QFD to road maintenance services, we focused on winter maintenance, including snow removal and ice control in Sapporo. Such maintenance is greatly affected by weather, an uncontrollable external factor, and its outputs and outcomes are difficult to measure. We chose winter maintenance as an example of QFD application, because any method that is applicable to winter maintenance promises to be applicable to road maintenance in general as well as to many other government services.

4.3 Weather and Winter Maintenance Costs in Sapporo

Sapporo is one of the snowiest cities of its size (population: 1.8 million people) in the world. The capital of Hokkaido, Japan's northernmost prefecture, Sapporo often records annual snowfall in excess of 5 m (Figure 2, Sapporo Meteorological Observatory, 2004)[10].

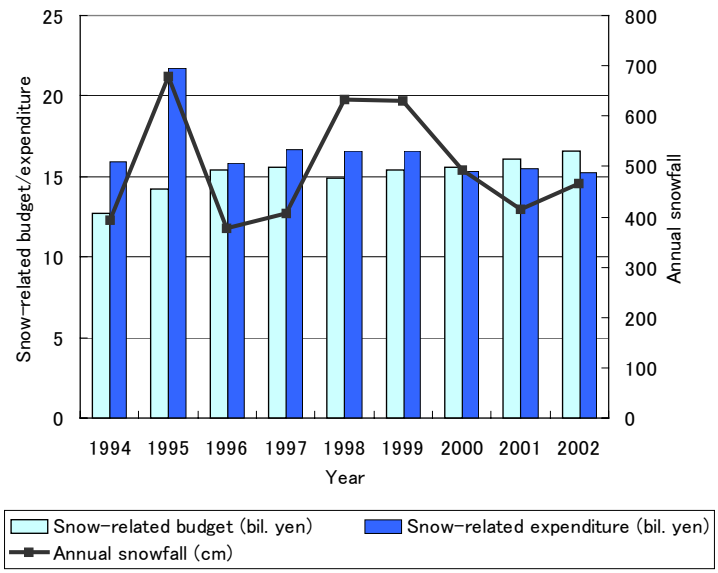

Figure 2. Annual Snowfall and Snow-related Budget/Expenditure

Regardless of the great sums (US$140 million in FY 2002, Sapporo City, 2004)[12] spent on winter road maintenance overall satisfaction with winter road maintenance is low. Customers have identified it as the leading concern for the past 26 years in the city's annual opinion poll (Sapporo City, 2004)[11]. Budget constraints do now allow the city to raise expenditures on winter maintenance toward improving overall service levels. Consequently, more efficient and effective winter maintenance is required if the city is to improve the customers' satisfaction.

4.4 Collection of VOC

To analyze the needs of all the resident segments, it is desirable to collect VOC from each. However, in designing a new product, the focus tends to be on a specific market segment. This is because in order to successfully develop a new product, you cannot meet every need of the broader market but should meet the needs of a focused, specific market segment. We followed that custom and focused on businesses, a road user segment. A method in which

QFD is successfully applied to a specific road user segment can be applied to other segments.

The reasons for selecting businesses as our target segment are that all residents depend on the merchandise and services provided by businesses. The winter transportation costs incurred by businesses are reflected in consumer prices. Thus the winter road conditions determine the city's economic soundness, which ultimately affects quality of life and the well being of the community.

In 2001, we made a survey to reveal the importance rankings of winter traffic issues by expanded contributive rule (ECR) for businesses in Sapporo. The survey identified "reduction of business efficiency due to winter delay" as the second most problematic winter traffic issue for businesses, after "increased danger of traffic accident" (Yamamoto, C. et. al., 2004)[16]. Because these two issues are closely related each other, we assumed that the road users' winter maintenance need is to achieve the road condition where the causes for winter delay are removed, and we surveyed the causes of winter delay experienced by businesses. We selected "reasons for winter delay" as the key in identifying winter traffic issues.

4.5 Survey Outline

A winter transportation behavior survey (Figure 3) was given to the person in each business who is responsible for traveling to the bank and to the client to collect money and make payments. The survey date was February 25, 2004 (Thursday). Such personnel were selected because in Japan, the 25th is the second-busiest day of the month (after the last day of the month) for personnel in charge of money matters, so their transportation behavior is expected to remain largely unchanged from season to season, and because every business has such personnel. Making payment without a delay, especially for promissory notes, is critical for any businesses.

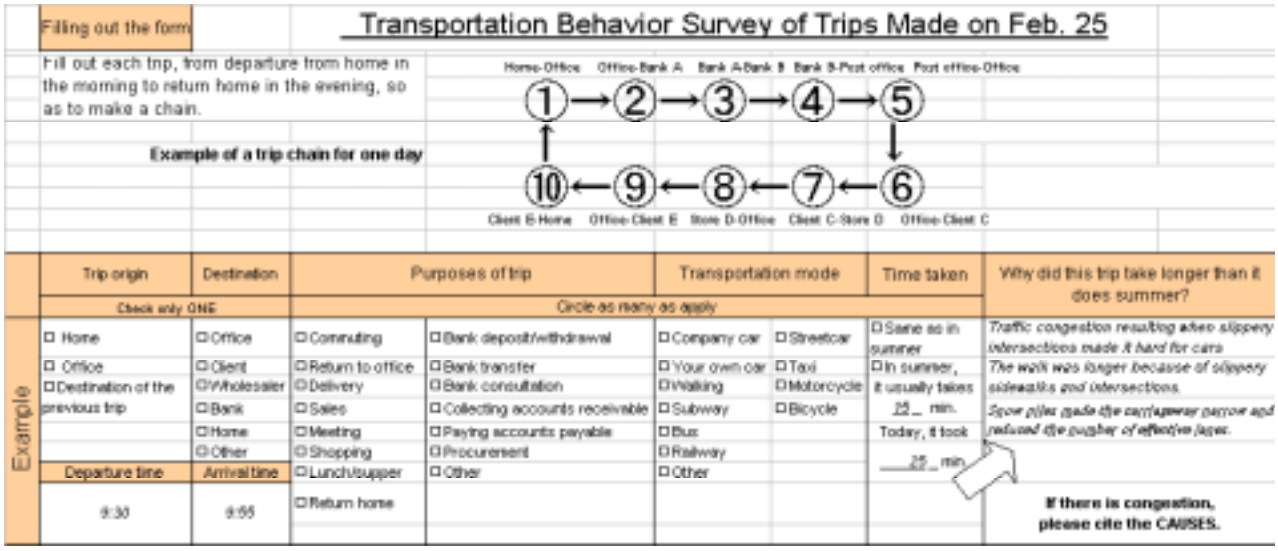

Figure 3. Transportation Behavior Survey

The transportation behavior of each respondent was surveyed on a trip-by-trip basis. The survey queried departure/arrival times, transportation mode, trip purposes, whether the trip took longer than in summer, and causes for any reported winter delay. A trip that took longer on the survey date than in summer was said to incur a "winter delay." Respondents who reported such delay were asked to write down the reasons, which were used as the VOC. Questionnaires (Figure 3, 568 questionnaires) were sent by post or handed out to businesses in Sapporo from February 20 to 23, 2004. Respondents numbered 259 (response rate: 45.6%.)

5. QFD PROCEDURE FOR AND EVALUATION OF WINTER MAINTENANCE

5.1 Outline

Figure 4 (a) is the flow of QFD conducted for winter maintenance in this study. Figure 4 (b) shows phases of QFD corresponding to the numbers in the following process. In this paper we used QFD free software developed by Shindo, et al. (2001)[14].

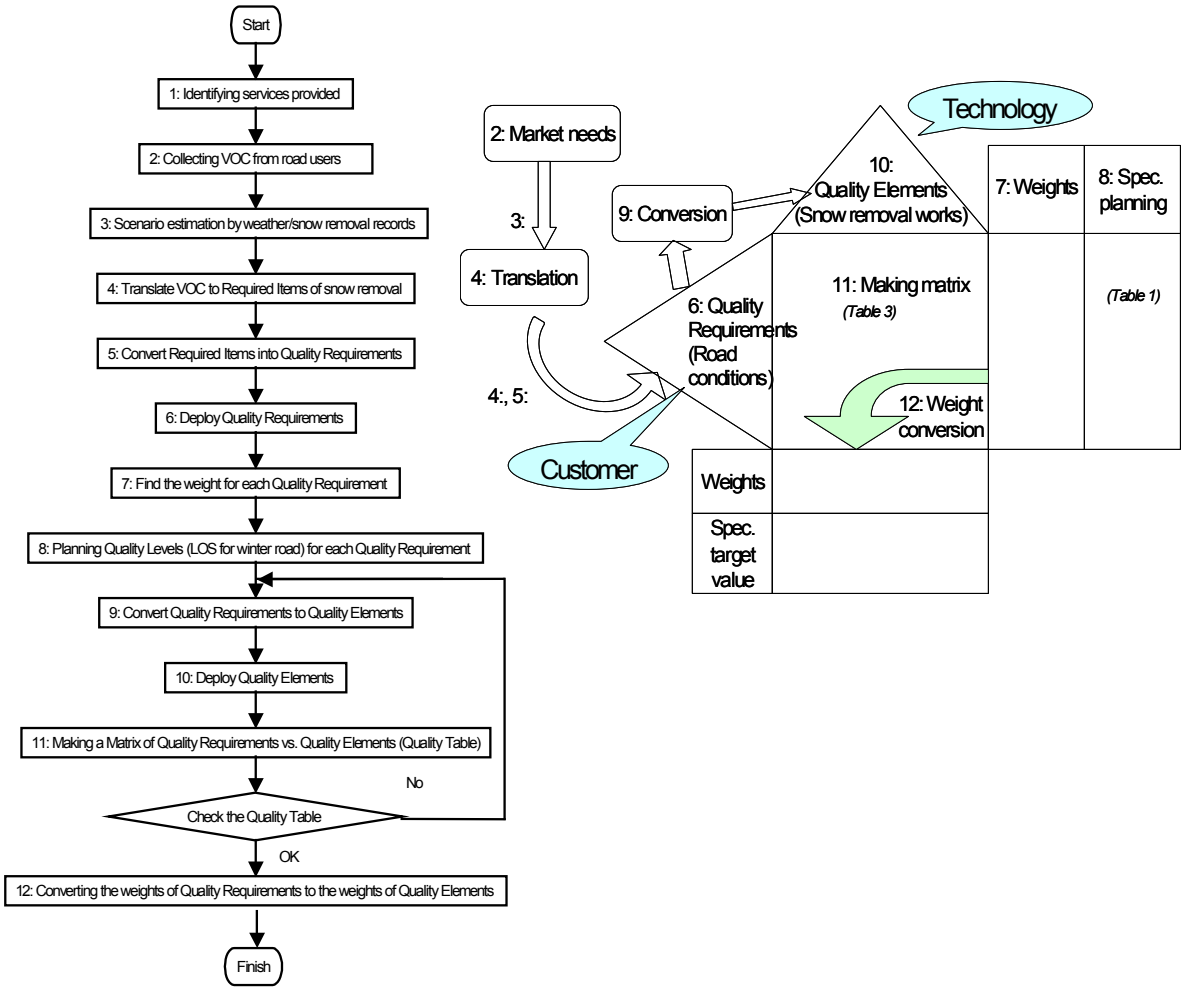

Figure 4 (a). Flow Figure 4 (b). Visual Presentation

Figure 4. QFD Conducted for Winter Road Maintenance

5.2 QFD Procedure for Winter Road Maintenance

1) Identify the services to be provided

The service to be provided is "winter maintenance that secures the traffic flow of vehicles and people in the city."

2) Collect VOC from road users

Data were collected in the Winter Transportation Behavior Survey conducted on February 25, 2004. Respondents' notes on "reasons for winter delay" were used as VOC.

3) Develop a scenario

Through various combinations of "WHO," "WHEN" and "WHERE," use of the product is imagined. In this study, the collected VOCs consist of every reason for winter delay. To understand the circumstances of a delayed trip, weather data (Sapporo Meteorological Observatory, 2004)[10)] and winter maintenance data on February 23, 24 and 25 were collected.

4) Convert VOC into required items of winter road maintenance

The VOCs are broken down into "Required Items" (i.e., the "true" needs of customers), which are then integrated with each other. In this study, using keyword analysis, "road conditions under which winter delay occurred" were identified (left column in Table 1). Required Items are the road conditions under which the causes of delay have been removed.

5) Convert Required Items into Quality Requirements

A Quality Requirement is a clear (unambiguous) expression of quality to describe a Required Item. In this study, Quality Requirements are defined as road conditions that would prevent delay, each corresponding to a "reason for delay" (items below "Quality" in Table 1). Quality Requirements were selected by transportation mode and then combined.

6) Deploy Quality Requirements

In general, Quality Requirements are deployed into more general items to form a hierarchy structure of three layers. However, in this study, all the Quality Requirement items were used without deployment.

7) Determine the weight for each Quality Requirement

The weight of each Quality Requirement represents the magnitude of market demand for that Quality Requirement. Of the 777 trips reported by the respondents, 705 trips specified departure/arrival times and 348 trips (49.4%) were reported to have a delay compared to summer. Reasons for delay were obtained for 302 trips. We obtained the weights of Quality Requirements by calculating duplication frequencies of Required Items in VOC (Table 2).

Table 1. Quality Planning Table

Quality \ Quality Plan		Degree of Importance	Competitive Analysis	Current level	Plan	Quality Plan	Improvement Rate	Sales Point	Weight	Absolute Weight	Relative weight (%)
1. Addressing increased traffic needs	1	3		1		3	3.0	○		10.8	8.0
2. Smoothing traffic flow in the CBD	2	1		2		2	1.0			1.0	0.7
3. Eliminating vehicles parked such as to hinder traffic flow	3	2		1		3	3.0			6.0	4.4
4. Securing road width	4	9		6		7	1.2	◎		15.8	11.6
5. Securing necessary numbers of lanes	5	3		3		4	1.3			4.0	3.0
6. Securing sight visibility	6	2		3		3	1.0			2.0	1.5
7. Ensuring that snow remaining after plowing does not narrow any road sections	7	2		2		3	1.5			3.0	2.2
8. Securing two-way road width at narrow road sections	8	2		2		3	1.5			3.0	2.2
9. Stopping and starting easily at intersections	9	1		5		6	1.2			1.2	0.9
10. Ensuring vehicles are not hindered from going straight at intersections	10	2		3		3	1.0			2.0	1.5
11. Ensuring that driving is not hindered by snow and ice on roadway	11	8		4		4	1.0			8.0	5.9
12. Completing the plowing of freshly fallen snow on roadways	12	8		3		4	1.3	◎		16.0	11.8
13. Completing the removal of slush from roadways	13	1		2		2	1.0			1.0	0.7
14. Securing road surfaces that are neither rutted nor greatly uneven	14	3		5		8	1.6	◎		7.2	5.3
15. Maintaining adequate road surface friction	15	7		4		8	2.0	◎		21.0	15.5
16. Conducting snow hauling only during hours in which companies are not busy	16	1		1		2	2.0	○		2.4	1.8
17. Securing visibility even during snowfall	17	1		2		1	0.5			0.5	0.4
18. Securing punctual operations of the mass transport system	18	4		3		8	2.7	◎		16.0	11.8
19. Providing information on vacant parking lots	19	1		2		2	1.0			1.0	0.7
20. Maintaining walkability at intersections and roadsides	20	1		3		5	1.7			1.7	1.2
21. Completing the removal of freshly fallen snow from sidewalks	21	3		4		5	1.3			3.8	2.8
22. Eliminating slush and melted snow on sidewalks	22	1		1		2	2.0			2.0	1.5
23. Maintaining adequate sidewalk surface friction	23	3		3		5	1.7			5.0	3.7
24. Ensuring that water does not pool at intersections or on roadways	24	1		2		2	1.0			1.0	0.7

The weights were given in 8 levels at increments of 5%. Because there were many items under 5%, an additional category of “less than 2.5%” was set to make 9 levels in total. “Taken-for-Granted” Quality was examined. These were taken for granted: absence of rutting, adequate road surface friction, absence of newly fallen snow on roads, sufficient effective road width. The weights for Quality Requirements related to these were set two levels higher than those of the frequency-based calculation (Table 2). The obtained weights of Quality Requirements under “Degree of Importance” were input in the Quality Planning Table.

8) Set Quality Plan values (LOS for winter road) for each Quality Requirement

Quality plan values mean market (or user) evaluation for the quality items. In this study, we set quality plan values as follow: Lack of satisfaction can be major (dissatisfaction) or minor (unsatisfaction). Our 2001 survey (Yamamoto, et. al)[16] found road users’ satisfaction level on the winter delay as shown in Figure 5.

The areas left or below blue and left-pink lines indicate people who are satisfactory and "somewhat satisfactory" with the winter delay level given on the axis of abscissas,

Table 2. Calculation of "Degree of Importance"

	Required Items	No. of trips	Ratio over total trips	Ratio over delayed trips	Ranking	Weight	"Taken-for-Granted "Quality	"Taken-for-Granted" Quality incorporated weight
1	Increased traffic	34	4.8	9.8	6	3		3
2	Congestion in CBD	6	0.9	1.7	16	1		1
3	Parking vehicles on roadsides	13	1.8	3.7	11	2		2
4	In proper width	98	13.9	28.2	2	7	◎	9
5	Reduced No. of lanes	31	4.4	8.9	7	3		3
6	Snow piles reduce sight	10	1.4	2.9	13	2		2
7	Narrowed road sections	9	1.3	2.6	14	2		2
8	Hard to pass each other	14	2.0	4.0	10	2		2
9	Slippery intersections	5	0.7	1.4	17	1		1
10	No dedicated lanes for right/left turn at intersections	10	1.4	2.9	12	2		2
11	Snow and ice on road	128	18.2	36.8	1	8		8
12	Remaining snow after plowing	73	10.4	21.0	3	6	◎	8
13	Slush	4	0.6	1.1	18	1		1
14	Unevenness	4	0.6	1.1	18	1	◎	3
15	Slippery road	65	9.2	18.7	4	5	◎	7
16	Snow hauling operation	3	0.4	0.9	19	1		1
17	Reduced visibility	2	0.3	0.6	20	1		1
18	Delay of bus/streetcar	40	33.0	11.5	5	4		4
19	Crowded parking lots	2	0.3	0.6	20	1		1
20	Intersections and roadsides hard to walk	2	0.3	0.6	20	1		1
21	Snow on sidewalks	23	3.3	6.6	8	3		3
22	Slush on sidewalks	7	1.0	2.0	15	1		1
23	Slippery sidewalks	20	2.8	5.7	9	3		3
24	Water pools	3	0.4	0.9	18	1		1

respectively, while areas right or below green and right-pink lines indicate dissatisfactory and "somewhat unsatisfactory", respectively. The point of intersection between blue and left-pink lines indicates when winter delay is less than 35%, the number of people who are satisfied with the delay are more than that of somewhat unsatisfied. Then, the trips with winter delay of less than 35% are ranked as the best satisfaction level "5". At the intersection between blue and green lines (winter delay: 47%), the numbers of people those who satisfactory and

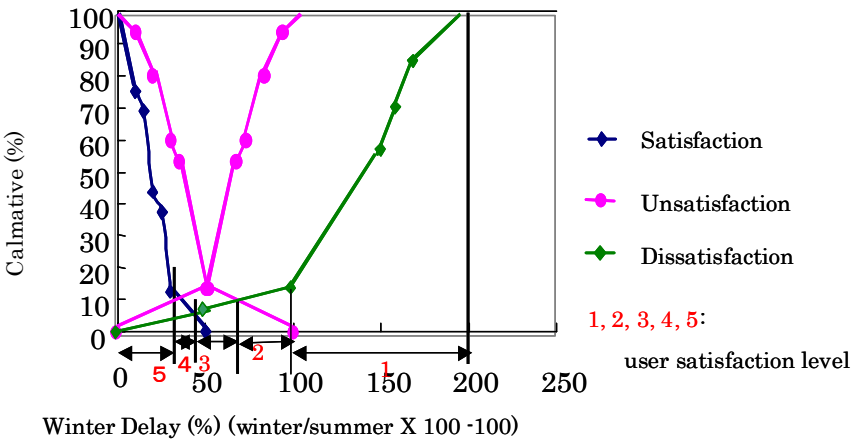

Figure 5. Relationship between Winter Delay and Users' Satisfaction, Unsatisfaction and Dissatisfaction

dissatisfactory with the delay evens. Between winter delay of 35% and 47%, we rank "4." The intersection between left- and right-pink lines indicates that when winter delay is more than 52%, people who somewhat satisfactory is more than those somewhat unsatisfactory. We rank "3" for winter delay between 47% and 52%. Because at 65% delay, the number of dissatisfactory people is more than those somewhat unsatisfactory, we rank "2." Finally, because no one is satisfactory or even somewhat unsatisfactory when winter delay exceeds 100%, for which we rank "1." In this way, we evaluated each trip for the user satisfaction and the most frequent values are used as the value of user evaluation for each Quality Requirement (Our Company in Table 1).

"Sales Points" of the new products can be freely selected from Quality Requirements. Extra points can be added to bring the Quality Plan values into conformity with the marketing strategy. A value of 1.5 was given to the double-circled Sales Points and 1.2 to the single-circled ones, based on past experience. After giving Quality Plan values to each Quality Requirement, the Improvement Rates are calculated by dividing "Quality Plan values" by "Current Levels" (Table 1.) Then the Absolute Weight for each Quality Requirement is calculated as (Absolute Weight) = (Degree of Importance) X (Improvement Rate) X (Sales Points). The Relative Weight is the percentages of the Absolute Weight of the Quality Requirement over the total of Absolute Weights.

In our study, in completing the Quality Planning Table (Table 3), values for "the city's current levels" were given based on the winter maintenance expenditures for Fiscal 2002 (Table 2). For some Quality Requirements, there is no corresponding winter maintenance provided by the city. In such cases, we assigned a value of 0 to "the city's current level." Giving a value of 0 to Quality Requirement prevents inclusion of the item in the calculation of Absolute Weights; however, it clarifies that no policy currently responds to the user need.

Based on conventional policies of the city, "securing effective road width," "maintaining adequate road surface friction," and "completing the removal of freshly fallen snow from roads" were selected as Sales Points and double circles are given to these. Based on the survey, a double circle was also given to "securing punctual operation of the mass transit system," and a single circle was given to "addressing increased traffic needs" and "conducting snow haling only during hours in which companies are not busy."

"Reduction in number of lanes" and "insufficient road width" had high importance among VOCs. This suggests that there was reduced traffic capacity. Improving traffic capacity at intersections is more efficient in improving overall traffic capacity than is increasing the road width, because the former entails less snow-hauling amount. For road width-related and intersection-related Quality Requirements, we set their Quality Plan values one to two levels

Table 3. Quality Table

Quality \ Element		1 Roadway	2 Sidewalk	3 Intersection & snowmelt disposal	4 Snow hauling	5 Gridding/friction control	Degree of Importance	Weight (%)
1. Addressing increased traffic needs	1						3.0	0.0
2. Smoothing traffic flow in the CBD	2	◎		◎	◎	◎	1.0	0.9
3. Eliminating vehicles parked such as to hinder traffic flow	3						2.0	0.0
4. Securing road width	4	◎		◎	◎		9.0	13.7
5. Securing necessary numbers of lanes	5	△		○	◎		3.0	3.5
6. Securing sight visibility	6			◎	◎		2.0	1.7
7. Ensuring that snow remaining after plowing does not narrow any road sections	7	◎					2.0	2.6
8. Securing two-way road width at narrow road sections	8	◎		○	◎		2.0	2.6
9. Stopping and starting easily at intersections	9	○		○		◎	1.0	1.0
10. Ensuring vehicles are not hindered from going straight at intersections	10			◎			2.0	1.7
11. Ensuring that driving is not hindered by snow and ice on roadway	11	◎					9.0	7.9
12. Completing the plowing of freshly fallen snow on roadways	12	◎					8.0	14.0
13. Completing the removal of slush from roadways	13	◎					1.0	0.9
14. Securing road surfaces that are neither rutted nor greatly uneven	14	◎					3.0	6.3
15. Maintaining adequate road surface friction	15					◎	7.0	18.3
16. Conducting snow hauling only during hours in which companies are not busy	16						1.0	0.0
17. Securing visibility even during snowfall	17						1.0	0.0
18. Securing punctual operations of the mass transport system	18	○		○	◎	○	4.0	14.0
19. Providing information on vacant parking lots	19						1.0	0.9
20. Maintaining walkability at intersections and roadsides	20	△	◎	○		○	1.0	1.5
21. Completing the removal of freshly fallen snow from sidewalks	21		◎				3.0	3.3
22. Eliminating slush and melted snow on sidewalks	22						1.0	0.0
23. Maintaining adequate sidewalk surface friction	23		◎			◎	3.0	4.4
24. Ensuring that water does not pool at intersections or on roadways	24			◎			1.0	0.9
Degree of Importance		26.6	4.8	14.8	14.4	10.3		
Weight (%)		34.5	5.3	19.1	21.3	19.8		

higher than "the city's current levels."

9) Convert Quality Requirements into Quality Elements

Technical elements that satisfy the Quality Requirements of the customer (or the market) were determined. In our study, the winter maintenance work items that satisfy the needs of the road users (= Quality Requirements) were selected as Quality Elements (Table 3).

Generally, Quality Elements should be selected such that all Quality Requirements are addressed. However, in our case, we used current winter maintenance work items as Quality Elements, even though it means that some Quality Requirements may not be addressed and

the Quality Table of such Quality Requirements will be left blank. This is because the objective of QFD is to evaluate government services and there is the need to identify Quality Requirements that are not addressed by current government services. Some of the Quality Elements that are not addressed currently can be addressed by adding new works to the current winter maintenance work item. In such case, we assumed that the current work item addresses them.

10) Deploy Quality Elements

Generally at this stage Quality Elements are grouped by an affinity method, and a Deployment Diagram of Quality Elements is made. However, all the Quality Elements selected were used without deployment in this study (Table 3).

11) Make a Quality Table (Table 3)

A matrix called "Quality Table" was made for converting Quality Requirements (road user needs) into Quality Elements (winter maintenance items). The strengths of the relationships between each Quality Requirement and Quality Element were given. City government officials who had experience working in winter maintenance divisions assisted in rating the relationships.

12) Check the Quality Table

Absence of a Quality Element that satisfies the Quality Requirements indicates that current winter maintenance by the city does not address that road user's Quality Requirements.

13) Convert the weights of Quality Requirements to the weights of Quality Elements

The strength of the relationship between each Quality Requirement and Quality Element were indicated with a double circle (strength of 5), single circle (strength of 3), triangle (strength of 1), or nothing (strength of 0). According to the strengths of the relationship between the Quality Requirement and Quality Element, the weight of the former is allocated to the latter. The allocated weights of each Quality Requirements were added to calculate the Weights of Quality Elements (calculation results are shown at the bottom of Table 3).

14) Design Quality based on weights of Quality Elements

The calculated weights of Quality Elements were compared to the budget allocated to each winter maintenance work by the city government to determine their correspondence (Figure 6). Assuming that greater importance of winter maintenance work translates into greater budget allocation, little or no difference indicates fulfillment of road users' requirements.

5.3 Evaluation of Winter Maintenance in Sapporo by QFD

According to the comparison between the budget allocated to each winter maintenance work

and Weights of Quality Elements obtained by QFD based on user needs, the budget allocation for measures against very slippery road conditions should be 19.5% (currently 9.4%) and that for intersection snow removal should be 21.5% (currently 3.5%). The later includes the effect of inclusion of frequent snow hauling from intersection corners in current intersection snow removal.

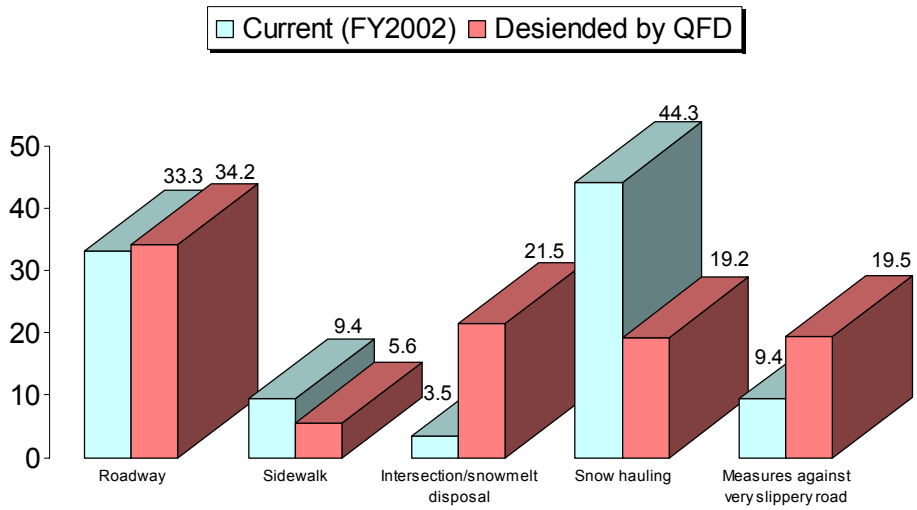

Figure 6. Comparison between Current and Designed Budget Allocations

The customers' needs that have not been addressed by current winter maintenance works are identified in Quality Table (Table 3). Such Quality Requirements are 1) slush removal from sidewalks and 2) snow removal standard that meets the increased traffic volume on days that are busy for businesses. The 25th is the second-busiest day of the month for businesses; thus, it needs to have a higher snow removal standard. The current snow removal standard is the same for every day of the month. Also, snow hauling from residential roads should not be carried out on such busy days.

The customers' needs that have not been adequately addressed by current winter maintenance works are: 1) measures against illegal parking at the roadside, including by vehicles making deliveries; and 2) intensive snow hauling from streetcar and bus routes. Removing snow from narrowed sections of bus routes is an important policy, but its implementation does not seem to be at a level that meets customers' needs.

Winter maintenance for sidewalks tends to be considered separately from that for roadways. However, the use of public transportation involves walking, so the pedestrian environment is important for public transportation users. The pedestrian environment includes roadsides and intersections where pedestrians walk along and across the road. Winter maintenance should address the need for overall trip efficiency and safety.

6. SUMMARY AND DISCUSSION

6.1 Summary

This study examined the applicability of QFD to government services using winter road maintenance as an example. In applying QFD we did as follows:

1) The weights of winter road maintenance items were used to design a budget allocation that would better meet road user needs. Then, the designed budget allocations were compared with current (2002) budget allocations by the City of Sapporo to evaluate current winter maintenance.
2) Using current winter maintenance work items for the Quality Elements, those Quality Requirements that have not been addressed by the current policy were identified.
3) The Quality Requirements identified a discrepancy between present service level and service level required to satisfy customers' needs, and the differences were quantitatively evaluated.

In applying QFD, the following advantages of QFD over conventional surveys of customers' satisfaction with government services, such as the CS Portfolio Analysis and AHP, were identified:

1) Elective questionnaires evaluate only items selected by the questionnaire developer. Open-end questions allow the surveyor to collect and evaluate a wider range of opinions.
2) Use of relative weights (%) allows identification of Quality Requirements that require special focus, as well limitation of the expenditure to within the total budget.
3) Incorporating “Taken-for-Granted” Quality, allows us to incorporate the importance of Quality Requirements that are considered fundamental but are not specified by VOC.

6.2 Discussion

QFD seems to be easily applied to government services whose final products are visible such as road maintenance, because identification of “Quality Elements” is easy. However it seems difficult to apply it to less tangible services, such as comprehensive policies, because it would require arduous explanation by the government official regarding selection of the Quality Elements that have been converted from Quality Requirements and the strengths of the relationships between them. Consequently, QFD seems to be useful for policy design but not for forming consensus among residents.

REFERENCES

1) Akao, Y., (1990), **Introduction to the Quality Function Deployment**, Nikkagiken Press, Tokyo, Japan (in Japanese)
2) Iyobe, S., (2000), **Basic Specification 51 -- QS 9000**, Nikkan Kogyo Shumbun Press,

Tokyo, Japan (in Japanese)

3) Joetsu City, (2002), **Report on the Citizens' Satisfaction on the City Services**, Website by the City of Joetsu at http://www.city.joetsu.niigata.jp/contents/town-planning/manzoku/manzokudo.pdf (accessed in December 2004), Joetsu, Japan (in Japanese)
4) Lowe, A. J., (2000), **Quality Function Development**, Website by the University of Sheffield at http://www.shef.ac.uk/~ibberson/qfd.html (accessed in December 2004), Sheffield, England
5) Miyagi Prefecture, (2004), **The Third Residents' Satisfaction Survey on Residents' Satisfaction on the Prefectural Services (FY 2004)**, Website by the Miyagi Prefecture at http://www.pref.miyagi.jp/hyoka/16mannzoku/16tyousahyo.pdf (accessed in December 2004), Miyagi, Japan (in Japanese)
6) Mizuno, S., and Akao, Y., (1978), **Quality Function Deployment**, Nikkagiken Press, Tokyo, Japan (in Japanese)
7) Japanese Standard Association, (2003), **Standard for Method Improving Performance of Management Systems**, Japanese Standard Association, Tokyo, Japan (in Japanese)
8) Ofuji, T., Ono, M., Akao, Y., (1990), *Quality Function Deployment (1) - Quality Table*, Nikkagiken Press, Tokyo, Japan (in Japanese)
9) QFD Institute (2004), "**QFD Institute website**", QFD Institute at http://www.qfdi.org/ (accessed in December 2004), U.S.A.
10) Sapporo Meteorological Observatory, (2004), **Metrological data at Website** by the Sapporo Meteorological Observatory at http://www.data.kishou.go.jp/ (accessed in December 2004), Sapporo, Japan (in Japanese)
11) Sapporo City, (2004), **Report on the Opinion Poll on the City Services** (FY 2003), The City of Sapporo, Sapporo, Japan (in Japanese)
12) Sapporo City, (2004), **Snow and Ice Control**, Website by the Snow and Ice Control Section, Construction Bureau of the City of Sapporo at http://www.city.sapporo.jp/kensetsu/yuki/ (accessed in December 2004), Sapporo, Japan (in Japanese)
13) Saaty, T. L, et al., "Modeling Behavior in Competition: The Analytic Hierarchy Process," **AMHCBQ** 16(1) 1-92, Vol. 16, No. 1. January. (1985)
14) Shindo, H., (2001), **Problem Solution by Designing Method Approach**, Nikkagiken Press, Tokyo, Japan (in Japanese)
15) Tokyo Data Bank, (2004), **On-the-Job Marketing Lesson**, Website in Tokyo Data Bank at http://www.tdb.co.jp/marketing/index.html (accessed in December 2004), Tokyo, Japan (in Japanese)
16) Yamamoto, C. et. al., (2004) "Importance of Winter Urban Traffic Issues and Performance Indicators as Rated by Businesses", **Proceedings of the Transportation Research Board Sixth International Symposium on Snow Removal and Ice Control Technology**, The US Transportation Research Board, Washington, D.C., U.S.A.