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Quality Function Deployment (QFD) in the BOCOMO projects: Basemap

It has been almost universally accepted nowadays that key to success in introducing new technology, as well as in business in general, is in understanding and meeting customer needs. BOCOMO projects undertaken by ICREST under the Raytheon's Synergy initiative represent a good example of interactive assessment of user requirements through a structured approach utilizing the elements of the Quality Function Deployment (QFD) methodology. The intent was to use the QFD methodology for further analysis of processes enhancing the acceptance of remote sensing technology by a target group - local governmental entities.

1. QFD: background

In terms of age, QFD is a relatively young technique. Its first use was reported in Japan in the late 60s, at the Kobe Shipyard. From there, the applications were further developed in various industries. In the mid 80s, Dr. Donald Clausing brought information on QFD to Xerox. From there a number of organizations have promoted and taught how to utilize QFD, the two most prominent organizations being GOAL/QPC and the American Supplier Institute (ASI). Nowadays QFD continues to attract a lot of attention in several industries. It is increasingly being recognized as an excellent means of ensuring that the "Voice of the Customer" directs the efforts of the complete organization. This usually results in providing products and services which are better accepted in the marketplace since they more accurately reflect what the customer is willing to buy.

QFD is a systematic approach mapping the customer's needs into definable and measurable product and process parameters, using matrices and other quantitative and qualitative techniques.

The thing that makes QFD unique is that the primary focus is the customer requirements. The process is driven by what the customer wants, not by innovations in technology. It tends to look beyond the usual customer feedback and attempts to define the requirements in a set of basic needs, which are compared to relevant technical information.

2. The Core QFD Matrix

The basic tool of analyzing customer requirements and deploying them into product or service is the Core QFD matrix. This matrix is a fairly flexible approach to implementing QFD that can be configured in different ways depending upon the purpose or application of the matrix. In fact, one of the keys to successful implementation of QFD is to adapt the basic matrices and procedures to the product, process, and project at hand. Working with the BOCOMO research teams we have utilized a combination GOAL/QPC call the A-1 matrix and what ASI calls the customer requirements matrix as an element of the "House of Quality" concept. (Fig.1, p.7). On the left side are customer needs ("Whats") reflecting the "voice of the customer", what the customer wants in the product. The top of the matrix shows technical characteristics ("Hows") that a research team can control in order to satisfy the customer's requirements. The right side of the matrix illustrates evaluation and prioritization of Whats and assigns the Importance Weight and the Relative Weight for each requirement. The body of the matrix shows relationship correlations between *what* the customer wants from the product and *how* a project team can meet those requirements. Relationships within this section are defined using a strong (●), medium (○), weak (△), or none (blank cell) scale. The peak of the matrix (the "Roof") is used to identify the interactions between different Hows and the relationships are rated as strong positive (●), weak positive(○), weak negative (△), strong negative (▲), and none. The bottom of the matrix is the prioritized and weighted technical requirements. It identifies the requirements that are the most critical for success, which is illustrated through a bar chart to provide quick analysis of the key technical requirements. This is followed by a concept evaluation section in which different system alternatives are compared for determination of how well technical requirements are met.

3. Customer needs (Whats): the "Voice of the Customer"

QFD relies upon the principle of listening to the "voice of the customer", a term used to describe what the customer desires from a product or service. There are different interactive techniques used to obtain this information. In the basemap project we went through three stages, each time increasing the level of detail and specificity of the customer needs: initial brainstorming sessions with all the users and project teams; focus groups' meetings with users interested in a specific application; phone and face to face interviews to verify the list of needs for completeness. As a result, a list of the following customer needs was developed:

- 1) To have a high-quality base map;
- 2) Maintenance: locally maintainable;
- 3) Maintenance: ability to modify if needed;
- 4) Currentness/timeliness of data;
- 5) Easy to use/access;
- 6) Cost-effective;
- 7) Seamless;
- 8) Providing opportunity for new applications/uses;
- 9) Group consensus on base;
- 10) Aesthetic/looks good;
- 11) Providing the opportunity to create derivative products;
- 12) Success.

It should be noted that not all of these needs are "spokens", i.e. explicitly stated customer expectations. Some of them are "expecters", the qualities a customer expects without telling, for example, #1 and #12 in the list above. Others can be classified as "exciters" (also referred to as "excitement" or "wow" factors), qualities a customer may not be aware of, but when they are present customers feel extremely pleased (#6, #8, #11).

The next step was to ask the customers to prioritize the list by assigning a numeric value (degree of importance) to each need. Also, the users were asked to assess their current level of meeting this or that need. Both ranking exercises were done through e-mail questionnaires using a scale from 1 to 5. That helped us to evaluate their current situation and determine the anticipated level in order to see how much improvement is needed or can be provided with the new product. The improvement ratio was obtained by dividing the anticipated level value by the current level rating. The next step was to determine the importance weight of the customer needs. It was calculated by multiplying the value of degree of importance times the value of improvement

ratio. Then importance weights were normalized into relative weights yielding percentages graphically represented in a bar chart. The process helped to determine which needs were the drivers for the technological development: besides two "expecters" (#1 - "to have a high-quality base map" and #12 - "success"), the top four customer needs included two "spokens" (#4 - "currentness/timeliness of data" and #9 - "group consensus on base"). The values of relative weights identified for customer needs will be used in prioritizing technical solutions, as will be shown below.

4. Technical requirements (Hows) and their relationship with customer needs (Whats)

Basically, Hows are ways of achieving Whats. By answering the question: "What can we control that allows us to meet our customers' objectives?" the project team identified twelve technical requirements including technical specifications/controls as well as service (training/education) and operational (implementation plan) elements. The next step was to fill out the relationship (central) area of the matrix by correlating technical requirements to individual customer needs in order to determine strength of relationship and impact on the need. Four symbolic and numeric measures were utilized:

- Strong relationship: ● = 9;
- Moderate relationship: ○ = 3;
- Weak relationship: △ = 1;
- No relationship: blank cell = 0.

The selection of the numeric values 9/3/1/0 is a relative weighting so that strong correlations are valued heavily while correlations that are weak or nonexistent carry little value. This system, as opposed to 5/3/1/0 or 4/2/1/0, is believed to better identify the drivers to the system providing greater separation between the technical solutions. After completion of the relationship area of the matrix, it was checked for completeness and adequacy. For example, a blank column for a technical requirement could indicate either a technical requirement that fulfills no customer needs, or, possibly, a perceived need for a technical requirement but the customer need had not been properly identified. In our case, there were no blank columns, nor rows in the matrix.

The next step was to prioritize technical requirements by determining the importance weight and the relative weight of the technical requirements. The importance weight was calculated as the sum of the value of relationship (9, 3, or 1) multiplied by the relative weight of the customer

need. For example, the importance weight of the first column "xy positional accuracy" was calculated as follows: $(9 \times 14.2) + (1 \times 4.2) + (1 \times 3.7) + (9 \times 6.4) + (1 \times 8.5) + (9 \times 14.2) + (1 \times 8.5) + (9 \times 12) = 446$. The relative weight represented a percentage of an individual weight of the total weight: Importance weight divided by the total weight multiplied by 100.

After determining the relative weights of the technical requirements we could identify the key technical solutions that could help satisfy the customer needs. The bar graph made it easy to see that three technical requirements - "co-registration: vector", "spatial resolution", and "xy positional accuracy" - ranked higher than the rest of requirements.

The highest ranking "co-registration: vector" reflects the issue of positional accuracy of the existing line-work within the vector data base and presents a major obstacle to the integration of remotely sensed data into existing GIS data base structures. Implementing this requirement, the research team developed a process and toolkit to aid local governments in building a singular base map to which the vector data could be migrated while maintaining the integrity of the relative positional accuracy of the vector line-work.

Interestingly, and not so obviously, the second highest ranking "trio" consisted of requirements-counterparts to the top three: "co-registration: IKONOS", "temporal resolution", and "edge matching". The sum of relative weights of these six highest ranking requirements showed that they accounted for 75% of the total. Despite the fact that the other requirements were not to be ignored, this implied that focusing on these parameters only would help meet 75% of the customer's needs. This led us to consider them "drivers" on the technical side and allowed further analysis on how different alternative map products (namely, traditional paper maps based on aerial photography, DOQQs, and a map based on high resolution satellite imagery) fulfilled these "winning" requirements. Quantitative comparison of values in the lowest (Concept evaluation) section of the matrix, conducted in the same way as the calculation of relative weights, revealed that satellite-derived basemap scored 379.5 points, DOQQs - 231.1 points, and paper map scored 182.7 points. The calculation illustrated and quantified the advantage of satellite derived data over alternative methods.

The "roof" of the matrix shows correlations among the technical requirements themselves based on the assumption that focus on increasing performance of a certain technical area can have both positive and negative impacts on other technical requirements. A positive relationship indicates that two Hows may have synergy, while a negative relationship indicates that two Hows may

have an adverse effect on each other. In the case of basemap, for example, the following technical requirements were identified as having strong positive relationships: "xy positional accuracy" and "edge matching", "GPS reference/control" and "spatial resolution", etc. On the other hand, "spatial resolution" and "Mr.SID/compression" were assigned a strong negative relationship, because the increased size of a high-resolution data file has an adverse effect on the compression capabilities of software.

5. Conclusions

The important point in gathering data for the QFD activity was to understand the needs of the customer fully involving him into the process and making him a part of the research team. Supporting techniques in developing a Core QFD matrix included brainstorming, focus group discussions, questionnaires, and interviews. These methods allowed to develop and organize information through a structured process and provide visualization of relationships at various detail levels. Most importantly, the QFD exercise provided the research team with, first, a prioritized list of what the customers wanted to see in the product, and, second, a prioritized list of technical parameters that the project team could control to satisfy the customer requirements. Quantitative analysis of customer needs and technical requirements allowed to evaluate the role high resolution satellite imagery, in comparison with conventional methods, could play in creating a high quality basemap for local planners and managers.

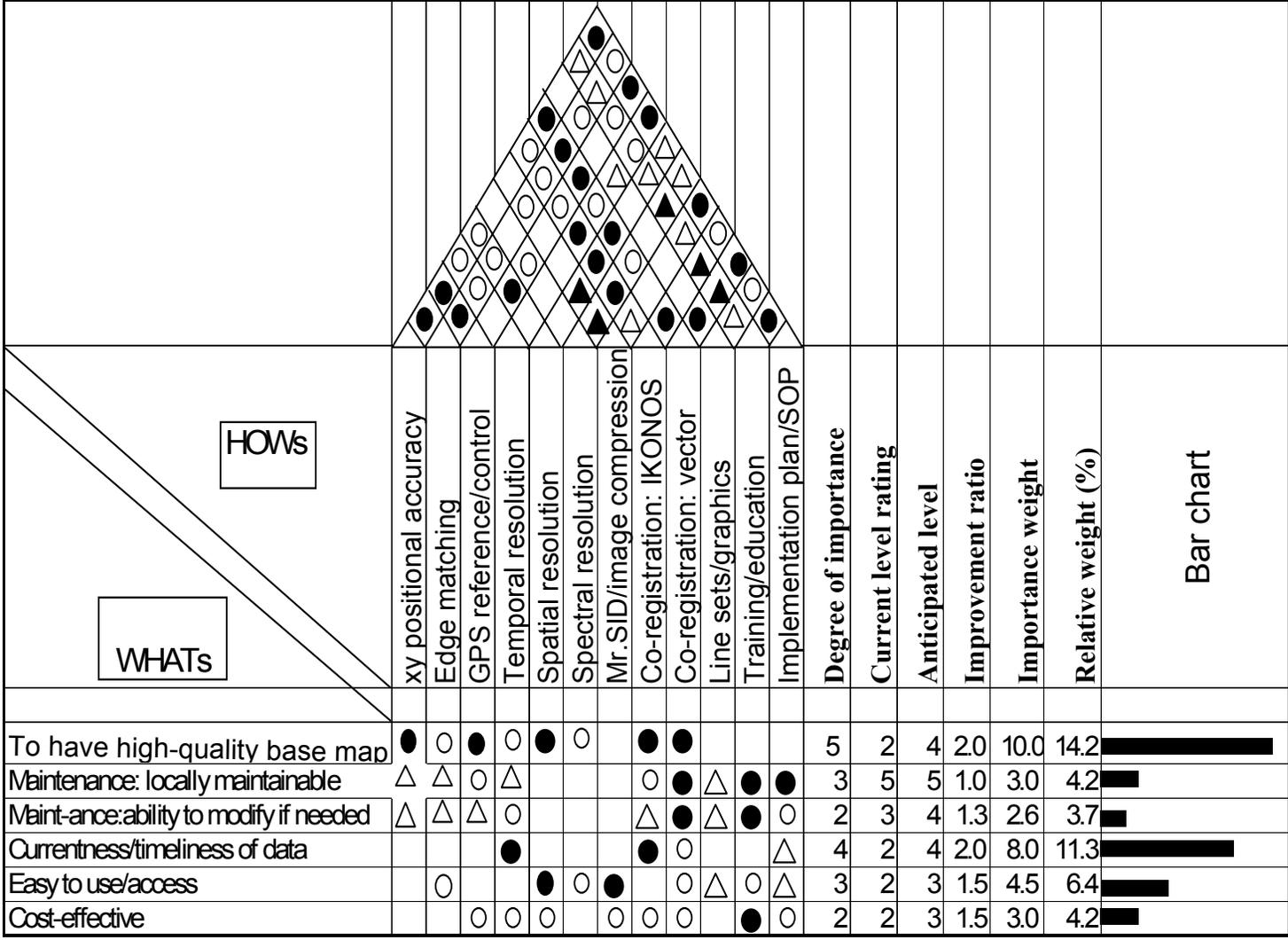


Fig.1. The Core QFD Matrix: Basemap.